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COTTON DUST CONTROLS IN YARN MANUFACTURING

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Consultants to this project were Dr. Parker C. Reist and Arthur C. Stern of the Department of Environmental Sciences and Engineering, University of North Carolina at Chapel Hill.

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Abstract

The project upon which this publication is based was performed pursuant to Contract No. HSM 99-72-44 with the National Institute of Occupational Safety and Health. The purpose of this work was the development of optimum design criteria for cotton processing machinery local exhaust ventilation systems. The systems were required to maintain the dust concentration in the work areas below 0.5 mg/m^3 as measured by the vertical elutriator. In mid-term, the objectives were extended to determine whether control to 0.2 or 0.1 mg/m^3 might be achieved by increasing air quantity handled by the capture devices. The project covered opening, picking, carding, drawing, and combing machines.

Drawings of dust capture devices for each of the subject machines are included. These drawings are similar in style and data provided to those used in "The Industrial Ventilation Manual", published by the American Conference of Governmental Industrial Hygienists. Cotton dust filtration is analyzed in depth including known characteristics of cotton dust and the characteristics of air cleaners as applied to the cotton dust control problem.

Carding, combing and drawing machines were isolated and detailed performance studies are reported covering dust capture devices attached to the machines. Numbers of complete operating textile mill lint and dust control systems were analyzed and reported. These systems included opening, picking, carding and combing production units.

Estimated costs covering complete lint and dust control systems are included. The conclusion is offered that cotton dust can be controlled in the subject areas to a level of less than 0.5 mg/m^3 (measured by the vertical elutriator) with commercially available equipment. It is recommended that this research be continued for the development of practical and economical capture and filter equipment which will accomplish better control of cotton dust particles of 15 microns or less.

Introduction

A number of studies in both the United States and foreign countries have shown that many of the employees of cotton mills suffer from a respiratory disease caused by inhaling dust in their working environment. This reaction, termed byssinosis, is typically an acute chest tightness in the cotton mill employees that recurs at the beginning of each work week and lasts one to two days in the early stages and eventually becomes a chronic, disabling, respiratory disease.

The agent in the dust believed responsible for the byssinosis reaction is not cotton fiber or fly, but rather a finely pulverized part of the cotton plant such as the bract. Mechanical cotton picking seems to increase the amounts of this agent gathered with the cotton. Until something is done to remove the byssinosis causative agent from the cotton before processing, it is necessary to capture and control the dust on the textile processing machinery to reduce the airborne concentration of respirable dust to a safe level.

The purpose of this project was to develop optimum design criteria for cotton processing machinery local exhaust ventilation systems. The design criteria will be used by cotton processors to gain the dust control in the working environment of their mills that is required by the Occupational Safety and Health Act of 1970.

The two principal areas of investigation were the configuration of exhaust hoods or other devices for capturing dust from cotton processing machinery and methods of filtering the particulate from the exhausted air. The dust capture devices and filters have been developed and specified as required to maintain the airborne dust concentrations in the work areas below 0.5 milligrams of dust per cubic meter of air. A supplemental extension of the project specified that the current equipment for cards, draw frames and combers be tested at elevated air quantities to determine whether dust levels of 0.2 and 0.1 mg/m³ might be achieved. Measurements were taken with the cotton-dust vertical elutriator.

The design specifications were developed and specified for opening, picking, carding, combing and drawing machines of the most common types currently used in manufacturing cotton yarns.

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General Comments

All of the dust control equipment and systems described in this report were made by the Pneumafil Corporation. This does not mean to imply that this is the only way to accomplish these objectives or that equipment and systems for these purposes are only available from the Pneumafil Corporation. There are many other contractors offering lint and dust control systems to the cotton yarn manufacturing industry.

Dust samples have been taken and reported before and after application of lint and dust control systems whenever this was possible. On some installations included in this report the control system was already installed and operating before it was decided to make it a part of this project. On many new installations the production machinery is also new and in this situation the lint and dust control system is applied before the production machines are started up. As a matter of fact, most of the new high speed production machinery cannot be operated efficiently without engineering controls for lint and dust emissions.

As directed, this study concentrated its attention on engineering dust controls for textile production machines in most common usage. Typical opening and picking machinery is shown in the "Terminology" section of this report. Cards in this category include those which are producing 40 lbs. per hour or less. Most common draw frames are two-delivery machines producing up to 800 feet per minute. A typical comber is shown in the "Terminology" section of this report. Although not part of the assignment some examples of newest technology have been included in the hope of providing some insight into the question of how a dynamic textile machine technology may affect the problem of controlling cotton dust.

All air quantities, drawings or other specifications listed in this report (unless otherwise noted) refer to production machinery in most common usage as described above and dust control to a level not exceeding 0.5 mg/m^3 as measured by the vertical elutriator. This was the originally assigned objective of this project.

During the dust sampling in producing textile plants described in this report machinery adjacent to the process being tested was in full production.

The project assignment specified dust sampling only with the cotton dust vertical elutriator and results should be evaluated on that

basis. High volume and OSHA area sampling results were reported to provide some figures for comparing the measurements of these various devices.

This report refers frequently to "dust capture systems" which applies only to the suction devices attached to the production machine to capture the dust as it is generated. A filter system is also required for a complete lint and dust control system that can capture the dust, filter the dust out of the air and return the air to the production area without exceeding the specified dust level in the working environment.

None of the dust control systems on industrial production units included in this report was designed to meet any specific dust level. All were designed to control only the visible lint and dust. Most systems now being installed and some already complete are being designed to control the dust to a specified level.

Conclusions

Engineering controls that will hold the dust concentration in the working environment of opening, picking, carding, drawing and combing below 0.5 mg/m^3 as measured by the vertical elutriator are feasible.

Engineering controls that can hold the median dust concentration to a level below 0.2 mg/m^3 as measured by the vertical elutriator in the working environment of drawing and combing are feasible. Practical addition of fine dust filters which are efficient on particulate sizes of 15 microns or less would make achievement of levels below 0.1 mg/m^3 (vertical elutriator) feasible.

Devices that will capture the dust at the points of generation on cards well enough to hold the median dust concentration to a level below 0.2 mg/m^3 in the carding environment as measured by the vertical elutriator are feasible. This does not take into account the need for filters that must clean the air from such devices to a level of less than 0.2 mg/m^3 before it is returned to the production area. Achievement of a median concentration of 0.1 mg/m^3 should result from careful modification of the type of devices described by this report and the addition of dust capture devices at other points of dust generation on the cards.

Opening and picking require more attention and effort to define devices that will capture the dust at the points of generation on the production machines well enough to hold the median dust concentration in the working environment to a level below 0.2 mg/m^3 and 0.1 mg/m^3 as measured by the vertical elutriator.

A practical application of fine-dust filters which are efficient on particulate sizes of 15 microns or less is a necessary addition to existing engineering controls for achievement of median dust concentrations of 0.2 mg/m^3 and 0.1 mg/m^3 as measured by the vertical elutriator in the working environment of opening, picking and carding. Refinement of existing coarse dust filters will make such application more economical.

Estimated Costs
Lint and Dust Control Systems

Prices are volatile and the evolution of systems and equipment design is dynamic. These figures should be used only as references for planning and not as specific values.

The figures include all dust-capture devices attached to the production machines, tubing and duct, preseparators, filters, fans, motors, controls, installation, air balancing, system start-up and check-out ready to run.

Not included in the costs are cutting, patching, painting or other building modifications and electrical wiring.

Cost of Lint and Dust Control Systems for Opening and Picking

Single-Stage Filters (18,500 to 76,500 cfm - Avg. = 42,179 cfm)

Number of jobs analysed.....	14
Minimum cost per cfm.....	\$1.11
Average cost per cfm.....	\$1.35
Median cost per cfm.....	\$1.35
Maximum cost per cfm.....	\$1.56

Two-Stage Filters (26,200 to 72,000 cfm - Avg. = 49,100 cfm)

Number of jobs analysed.....	12
Minimum cost per cfm.....	\$1.28
Average cost per cfm.....	\$1.60
Median cost per cfm.....	\$1.55
Maximum cost per cfm.....	\$2.00

Cost of Lint and Dust Control Systems for Cards

Single-Stage Filters (20,000 to 78,000 cfm - Avg. = 48,250 cfm)

Number of jobs analysed.....	14
Minimum cost per cfm.....	\$1.12
Average cost per cfm.....	\$1.42
Median cost per cfm.....	\$1.39
Maximum cost per cfm.....	\$1.76

Two-Stage Filters (28,800 to 144,000 cfm - Avg. = 86,733 cfm)

Number of jobs analysed.....	6
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Two-Stage Filters (28,800 to 144,000 cfm - Avg. = 86,733 cfm) con't

Minimum cost per cfm.....	\$1.42
Average cost per cfm.....	\$1.66
Median cost per cfm.....	\$1.56
Maximum cost per cfm.....	\$2.09

These figures are for systems designed to achieve a dust level in the working environment not exceeding 0.5 mg/m³ as measured by the vertical elutriator.

Recommendations

It is recommended that research and development as initiated in the performance of this project be continued. The purpose of the continued work should be to determine the requirements for practical engineering controls to achieve median dust levels of 0.2 and 0.1 mg/m³ as measured by the vertical elutriator in the working environment of opening, picking and carding areas in cotton yarn manufacturing plants. A special objective should be to achieve the desired dust levels at lowest economic impact on the industry.

The following program is recommended as a method of achieving the goals of such research and development:

I. Dust Capture Devices

A. Opening and Picking

1. Conduct a further study of dust emissions from production machines in most common usage.
2. Redesign dust capture devices described by the current project to achieve improved performance.
3. Design capture devices for application on other points of dust generation.
4. Analyze existing machine covers and internal structures and design modifications or replacements that will improve dust control.
5. Analyze evolving production technology to determine the magnitude of the dust control problem on new machine designs.

B. Carding

1. Test a system handling 1400 cfm (on a high-speed card running low-grade stock) consisting of a doffer plenum, a lickerin plenum and a coiler trumpet suction nozzle as described by the current project. Add an undercard plenum and a suction device between the flats at the top of the card.
2. If the system described above does not achieve the desired dust levels conduct a thorough study to locate dust emissions that are not under control of the system.
3. Analyze existing machine covers and internal structures and design modifications or replacements that will improve dust control.
4. Refine or extend the system to achieve the required dust levels.

5. Recognizing that cost is a function of air quantity, reappraise and improve designs for most efficient use of moving air.

II. Air Filter Systems

A. Coarse Dust Filters

1. Continue analysis and refinement of coarse dust filters currently in use on cotton dust control systems to optimize filter efficiency.
2. Determine best design, configuration and arrangement of coarse dust filters to achieve most practical and economical addition of fine dust filters.

B. Fine Dust Filters

1. Considering the characteristics of cotton dust and the production methods, equipment and facilities of the cotton yarn manufacturing industry, determine which type of fine dust filter offers the most practical application for control of particulate sizes of 15 microns or less.
2. Apply and test the chosen type of filter in an opening, picking or card room dust control system.
3. Refine the design and application of the filter to achieve dust control objectives at reasonable cost.

Description
 Lint and Dust Capture Devices for Opening & Picking

Most of the dust in the opening and picking process environment comes from open hoppers, feed tables, rake distributors, conveyers and from inefficient or poorly maintained filters that have been used for many years in these areas. Waste grinders also contribute their share of the problem.

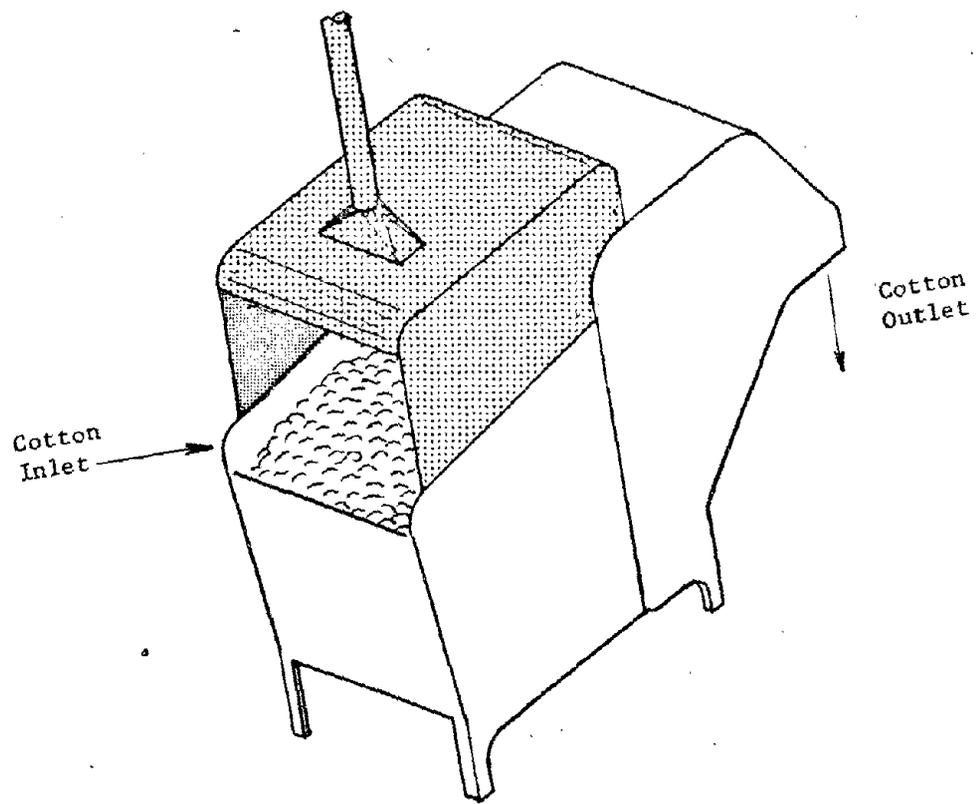
Modern lint and dust control systems applied to this problem capture the dust by placing suction hoods over the open hoppers, feed tables and other conveyers. Old style filters are completely eliminated and the fans are ducted directly into the new filter system. The waste grinder receives special attention. Some typical applications are shown on the drawings which follow.

Air quantities required for these applications are shown in the following chart.

Dust Control System Air Quantities
Opening and Picking

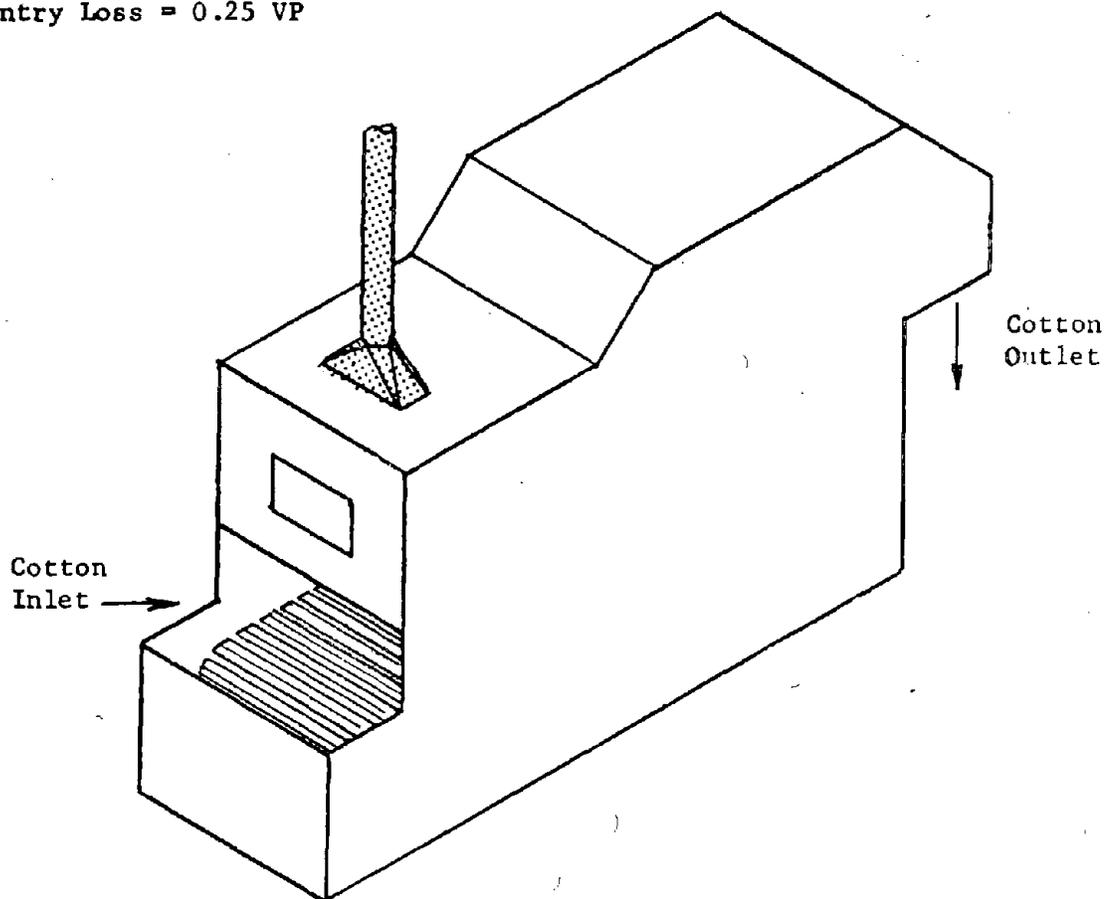
	<u>cfm Each</u>
Feed Hopper Hoods.....	500
Feed Table Hoods.....	500
#11 Condenser Fans.....	3000
Reserve-Hopper Hoods.....	500 or more
Picker-Beater Fans.....	1500
Waste Hopper Hoods.....	500
Waste Grinder Aspirator Fans.....	750-1000
Fiber Transport (depends on size and arrangement of system).....	3000-15000

$Q = 50-75 \text{ CFM/Sq. Ft. of Open Area}$
 $\text{Duct Velocity} = 2500-3000 \text{ FPM}$
 $\text{Entry Loss} = 0.25 \text{ VP}$



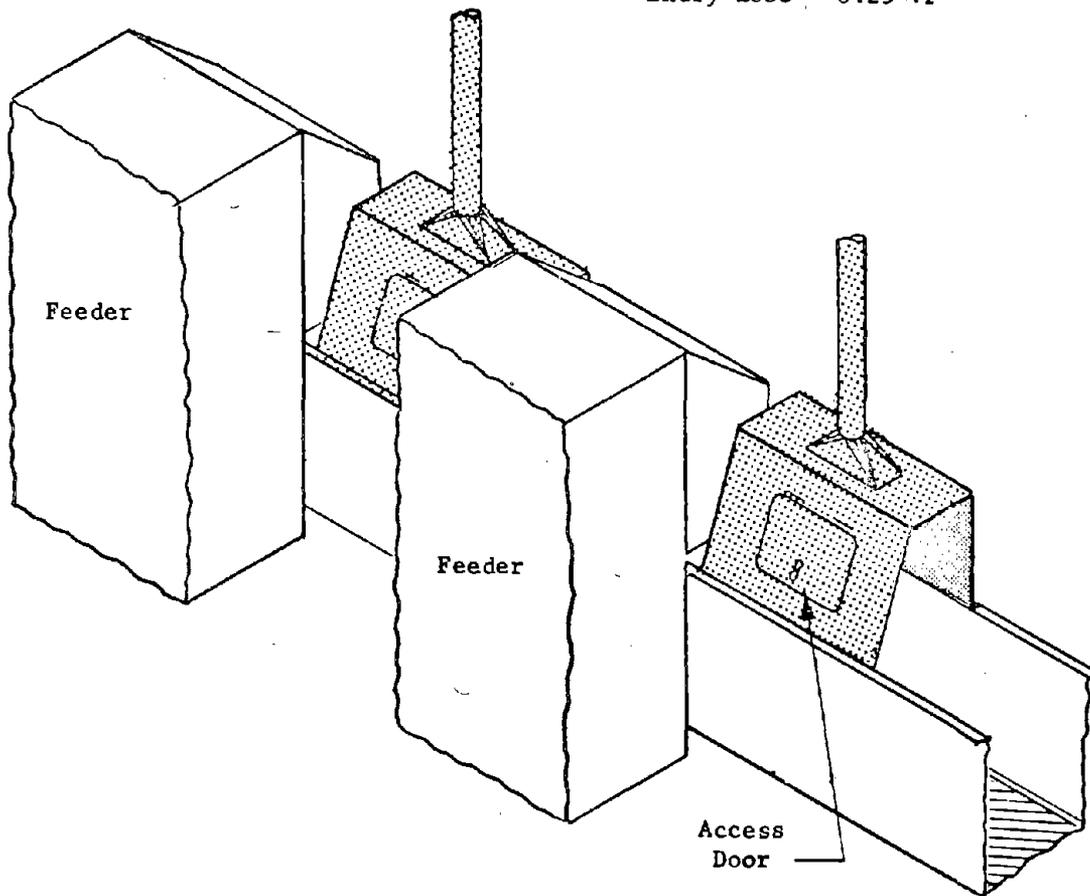
Feeder

$Q = 50-75 \text{ CFM/Sq. Ft. of Open Area}$
Duct Velocity = 2500-3000 FPM
Entry Loss = 0.25 VP



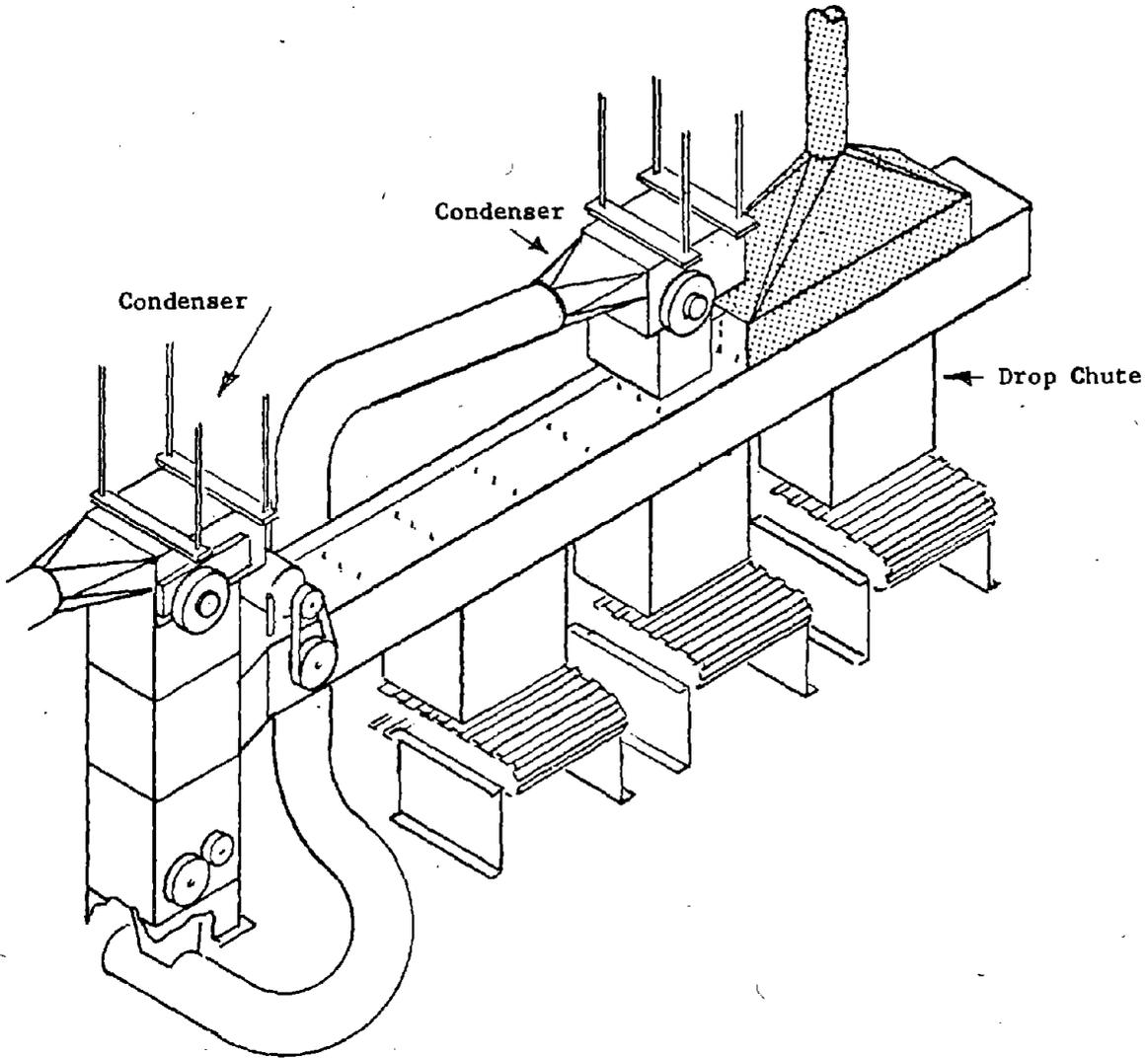
Cleaning and Blending Feeder

$Q = 50-75 \text{ CFM/Sq. Ft. of Open Area}$
 $\text{Duct Velocity} = 2500-3000 \text{ FPM}$
 $\text{Entry Loss} = 0.25 \text{ VP}$

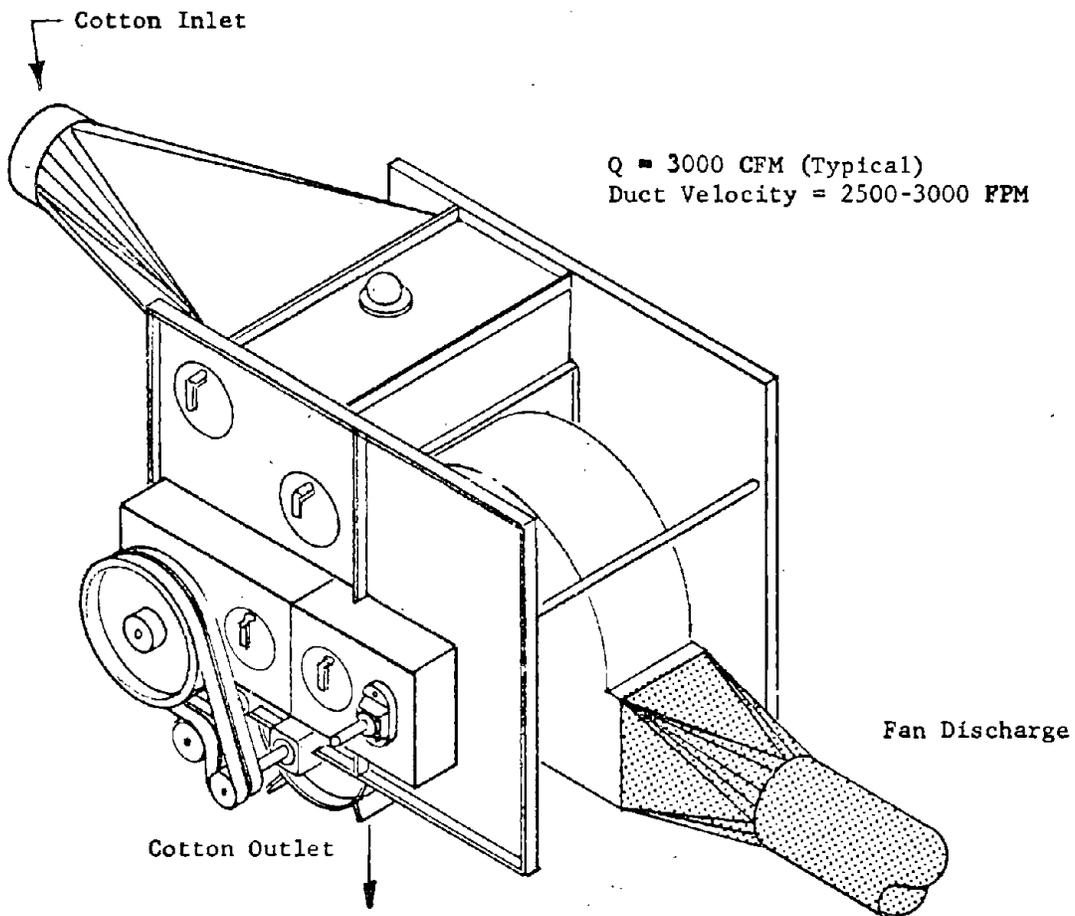


Feed Table Hoods

Q = 50-75 CFM/Sq. Ft. of Open Area
Duct Velocity = 2500-3000 FPM
Entry Loss = 0.25 VP

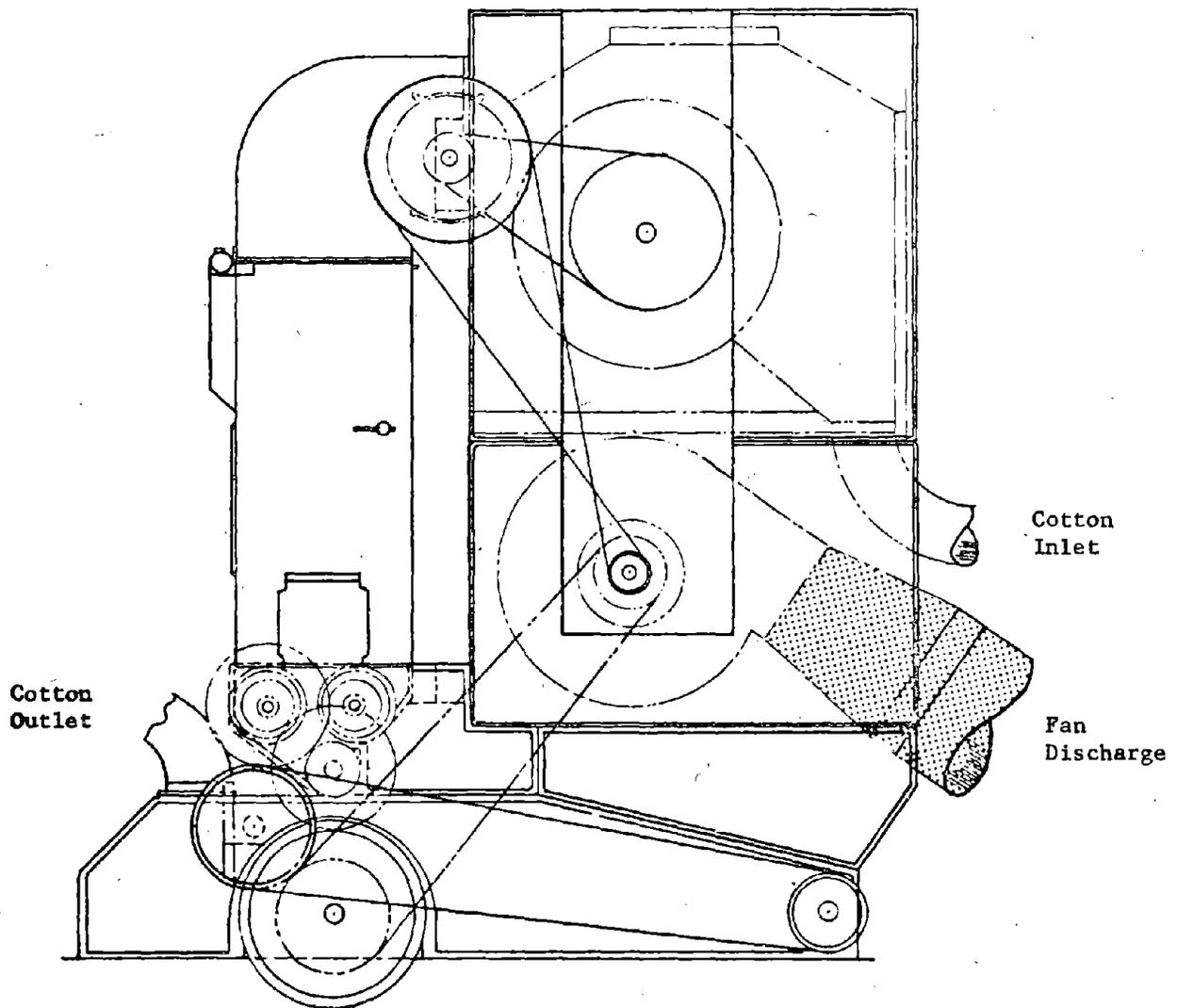


Rake Distributor



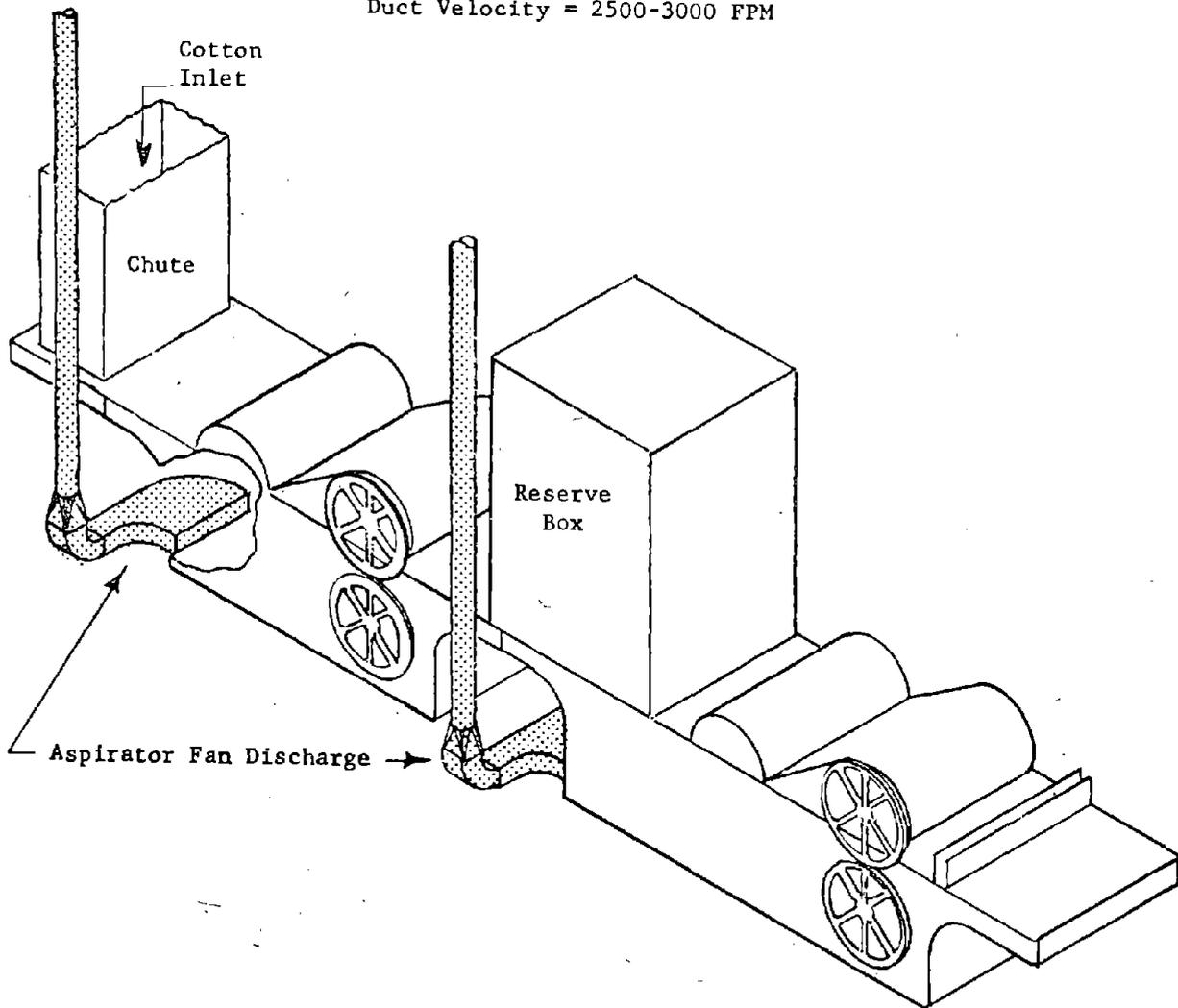
Dust and Waste Extractor (Condenser)

Q = 3000 CFM (Typical)
Duct Velocity = 2500-3000 FPM

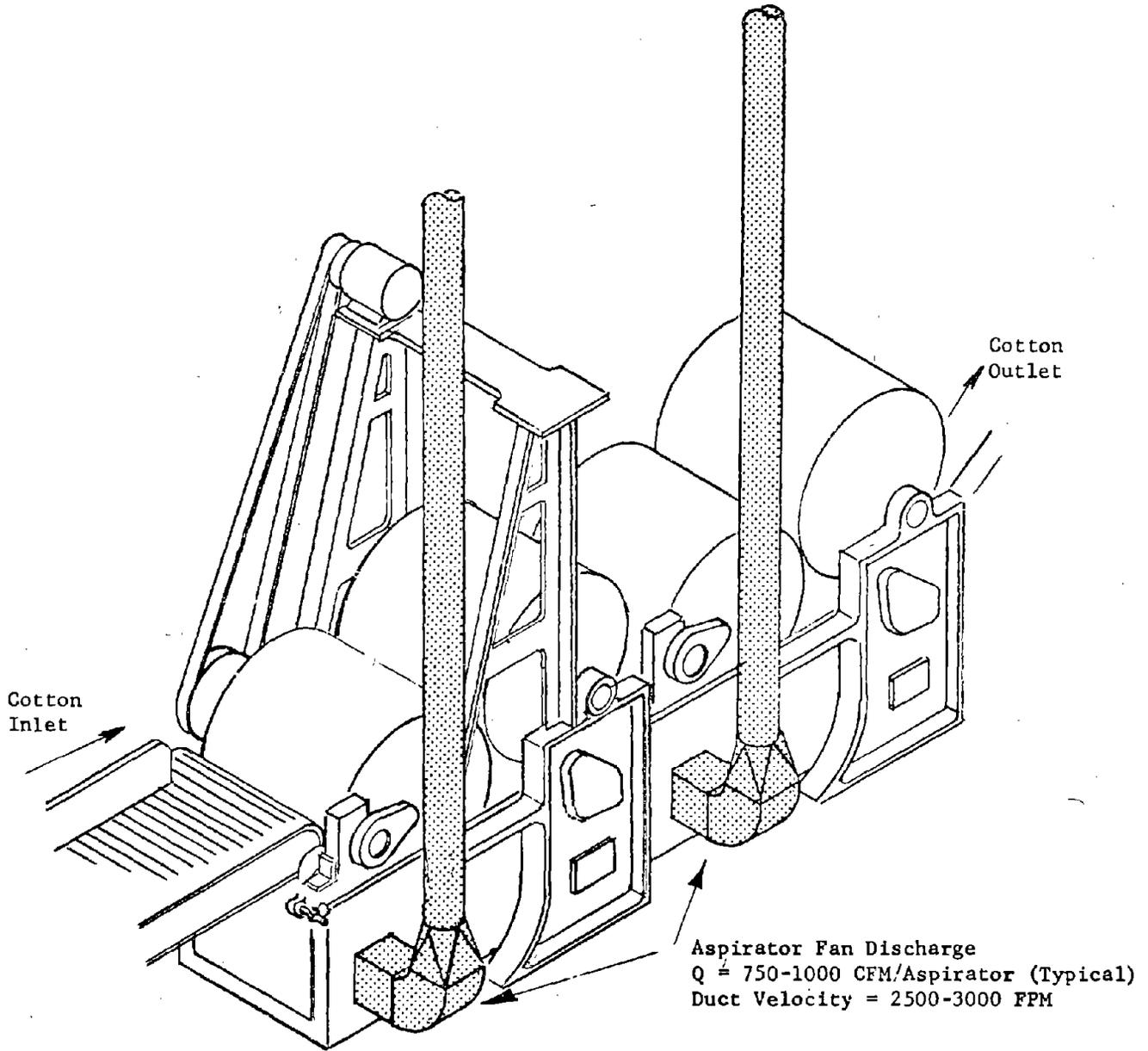


Lattice Opener with Dust and Waste Extractor (Condenser)

Q = 1500 CFM/Aspirator (Typical)
Duct Velocity = 2500-3000 FPM



Two-Beater Picker



Waste Opener

Dust Control System on Opening Line
at
Mill Code #8

Mill Code #8 manufactures fancy carded fabrics, 100% cotton, cotton and polyester blends, poplins, corduroys, oxfords, and crepes. The cotton was 1-1/16" staple strict low middling. During the tests, the blenders in front of sampling position #1 and #2 were running 100% cotton. The blender in front of sampling position #3 was not in operation. In front of sampling position #4, the stock was a blend of 50% cotton and 50% polyester.

Production Machinery Specifications and Arrangement. Please refer to the "Sampler Locations" drawing. This opening room was equipped with four lines of five blending hoppers each feeding into four modern cleaning lines to serve chute feed systems to 56 cards producing 42 lbs. per hour. The opening room is thus producing over 2,352 lbs. per hour.

Lint and Dust Capture System.

Suction hoods and direct connections to various machines for the capture of lint and dust along with the corresponding air quantities were as follows:

<u>Machine</u>	<u>Air Quantity - CFM</u>	
	<u>Each</u>	<u>Total</u>
#11 condensers (2)	3000	6000
Condensers in transport lines from blenders to cleaning equipment (4)	2000	8000
Condensers in transport lines from cleaning equipment to cards (4)	3000	12000
Hoods over feed tables and blending hopper lines (4)	4500	<u>18000</u>
Total		44000

This system was designed to clean up the visible lint and dust only.

Duct, Filter and Return Air System. Please see the "Sampler Locations" drawing for a schematic layout of the duct and filter system. This room was air conditioned with refrigeration, but the dust control system did not return through the air conditioning equipment. The dust control system air was returned directly to the room through ductwork separate from the air conditioning return air system.

The filter system was a continuous-automatic type consisting of a centrifugal lint preseparator followed by a rotary drum filter 7 ft. in diameter and 10 ft. long operating at 214 fpm face velocity. The lint from the preseparator and the dust from the stripper nozzle on the rotary drum filter was conveyed to a No. 6 condenser located immediately outside the apparatus room. All air coming from this No. 6 condenser was recirculated to the filter.

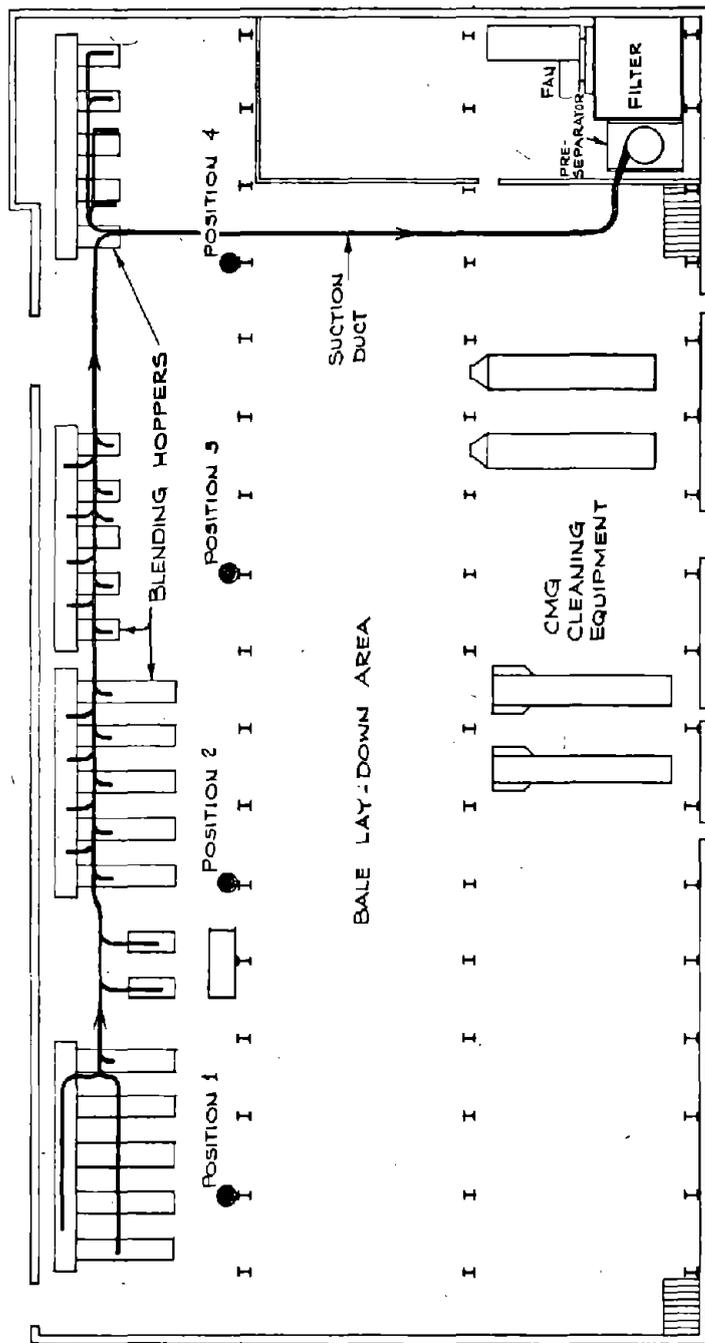
The lint and dust control system was installed during the first half of 1972.

Summary of the Test Data.

Vertical elutriator samples (mg/m^3) taken from 5/2/73 to 5/4/73. Positions #1, 2, 3 and 4 combined.

n = 12	Minimum = 0.30
\bar{x} = 0.37	Median = 0.36
σ = 0.05	Maximum = 0.45

Comments and Conclusions. This was a straight-forward job operating well below our project criteria of $0.5 \text{ mg}/\text{m}^3$ as measured by the vertical elutriator. It was an obviously well planned and well managed operation. It was a good illustration of the effectiveness of these continuous automatic systems, specified to control only lint and visible dust, on fine dust as well as lint and coarse dust.



MILL CODE 8 - OPENING ROOM
SAMPLER LOCATIONS

Dust Control System - Picker Room
at
Mill Code #31

Mill Code #31 manufactures cotton and polyester blended fabrics. Specifications on the raw material were not available.

Production Machinery Specifications and Arrangement. Please see the "Sampler Locations" drawings. The picker room had four two-beater pickers with material being supplied from two opening lines. The stock was drawn from the opening room via two Fiber Control fans, each handling approximately 3,500 cfm. The stock was then drawn from two reserve overflow hoppers to the pickers by one of three No. 11 condensers. The pickers were set up so that one feed line was feeding two pickers with a rake distributor and the other feed line was feeding two pickers with the material being drawn by individual No. 11 condensers. Originally, the air from the Fiber Control fans was filtered by conventional Fiber Control sleeve-type filters. The No. 11 condenser fans were filtered by No. 6/7 combination condensers and bag filters. The picker beater fans were filtered by No. 5 condensers. This picker room was air conditioned for both humidity and temperature control. The air conditioning system was handling approximately 28,000 cfm.

Lint and Dust Capture System. This system was designed to control the visible lint and dust only. It was installed early in 1973. Suction hoods and direct connections to various machines for the capture of lint and dust along with the corresponding air quantities are as follows:

<u>Machine</u>	<u>Air Quantity - CFM</u>	
	<u>Each</u>	<u>Total</u>
Two-beater picker fans (4)	1500	12000
Fiber Controls fans (2)	3500	7000
No. 11 condensers (3)	3000	9000
Hoods over waste feed hoppers (2)	500	1000
Hoods over waste grinder (2)	500	1000
Hoods over rake distributor (1)	500	500
Total		30500

Duct, Filter and Return Air System. Please see the "Sampler Locations" drawing for a schematic layout of the duct and filter system. The complete lint and dust capture system was ducted to one filter system. The lint preseparator and the filters were located in the room beneath the picker room. And, the picker beater fans as well as the Fiber Control fans were connected to underfloor duct. Other dust control connections were overhead in the picker room.

Upstream of the washer in the apparatus room were Auto-AIRMAT filters (American Air Filter Company). These were automatic, roll-up paper media filters for lint collection. However, at the time of testing, there was no filter paper on these filters. This was not checked out but it indicated that the air from the lint and dust control system was clean enough to protect the washer from undue maintenance without further filtration.

Summary of the Test Data.

OSHA General Area Samples (mg/m^3) taken 1/16/73 before installation of the lint and dust control system.

Summary of the Test Data. (continued)

Position #1 = 1.50

Position #2 = 1.43

Vertical Elutriator Samples (mg/m^3) taken from 1/17/73 to 1/19/73 before installation of the lint and dust control system.

n = 6

Minimum = 0.64

\bar{x} = 1.10

Median = 1.06

σ = 0.32

Maximum = 1.60

OSHA General Area Samples (mg/m^3) taken 2/14/73 after installation of the lint and dust control system.

n = 8

Minimum = 0.44

\bar{x} = 0.58

Median = 0.59

σ = 0.07

Maximum = 0.65

Vertical Elutriator Samples (mg/m^3) taken 2/15/73 and 2/16/73 after installation of the lint and dust control system.

n = 4

Minimum = 0.30

\bar{x} = 0.32

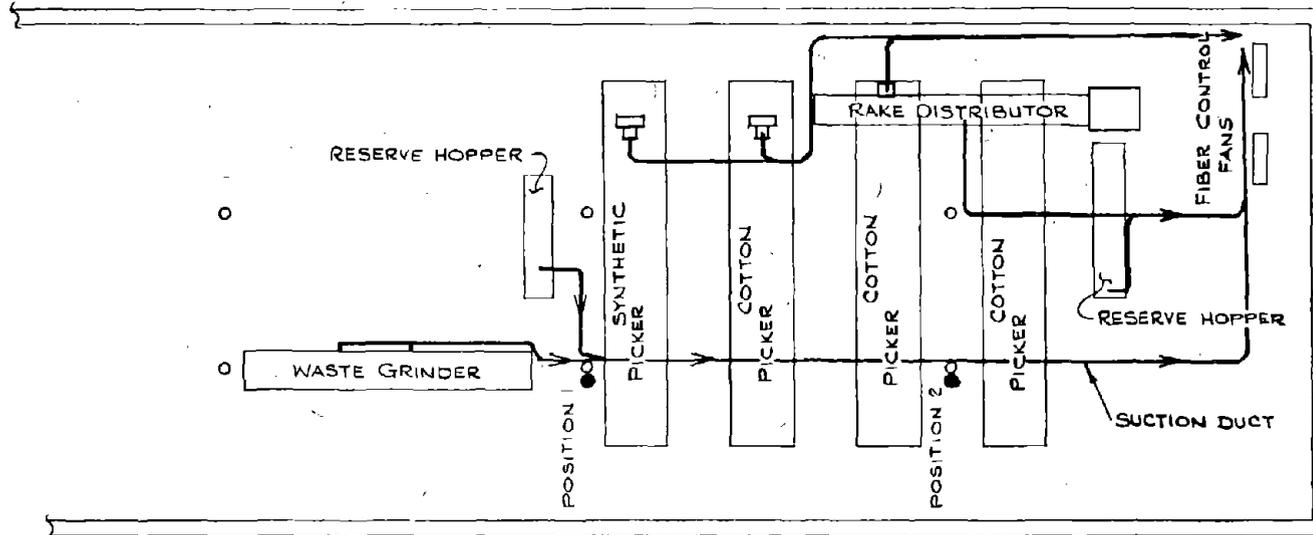
Median = 0.315

σ = 0.02

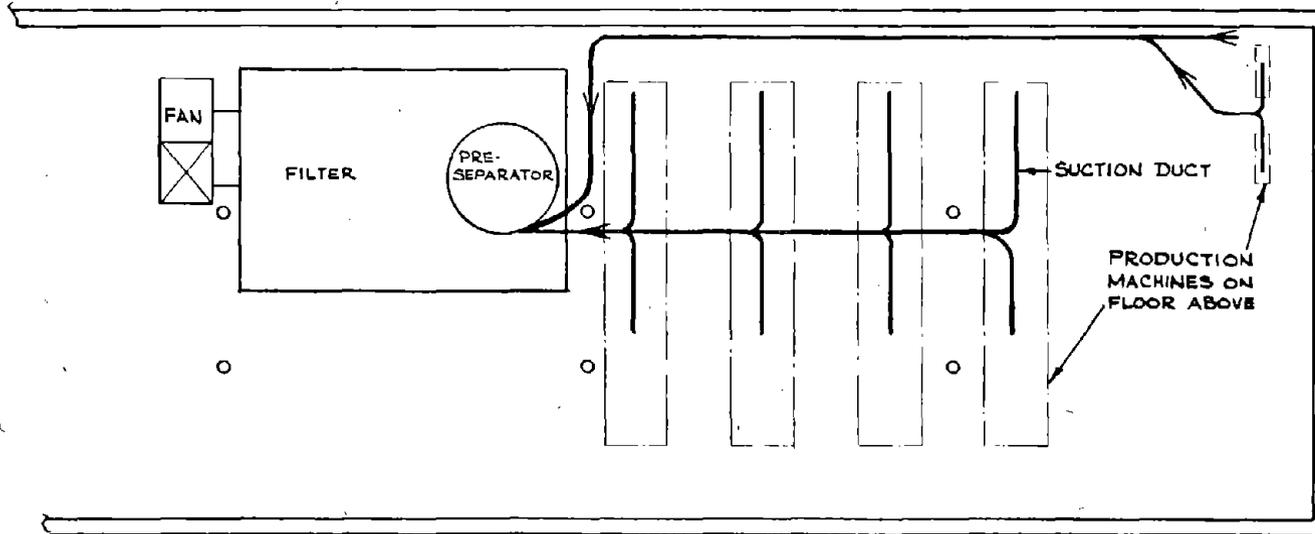
Maximum = 0.35

Comments and Conclusions. The data taken before installation of the lint and dust control system indicates that this was not a particularly severe dust control problem. OSHA General Area Samples taken after installation of the lint and dust control system show a dust level about 40% below the current OSHA standard of $1.0 \text{ mg}/\text{m}^3$. The system which was designed to control only the visible lint and dust has, therefore, reduced the theoretical total coarse and fine dust level by about 60%.

Comparison of the vertical elutriator samples before and after installation of the dust control system shows a fine dust reduction of about 71% based on the average figures. The controlled average is 36% less than the $0.5 \text{ mg}/\text{m}^3$ standard with this sampler. All of the test figures would have been better in some degree if the filters in front of the washer had been in operation.



MILL CODE # 31 - PICKER ROOM
SAMPLER LOCATIONS
(SEE ALSO "UNDER FLOOR DUCT" DRAWING)



MILL CODE # 31 - PICKER ROOM
UNDER FLOOR DUCT
(SEE ALSO "SAMPLER LOCATIONS" DRAWING)

Dust Control System on Opening and Picking
at
Mill Code #33

Mill Code #33 manufactures combed cotton knitting and weaving sales yarns from 100% strict middling cotton of 1-3/32" staple.

Production Machinery Specifications and Arrangement. The opening room was equipped with five model F5 Saco-Lowell blending hoppers, one waste grinder, one Saco-Lowell vertical opener, and two Saco-Lowell 11/12 Lattice openers. Please see the "Sampling Locations" drawing which shows the arrangement of this equipment.

Production was at the rate of 325 pounds per hour per picker making a 38" lap weighing 15 ounces per yard and 66 pounds per lap.

Lint and Dust Capture System. Suction hoods and direct connections to various machines for the capture of lint and dust along with the corresponding air quantities were as follows:

<u>Machine</u>	<u>Air Quantity - CFM</u>	
	<u>Each</u>	<u>Total</u>
#11 Condensers (4)	3000	12000
Picker Beater Fans (4)	1500	6000
Picker Hoppers (4)	400	1600
Feed Hoppers (5)	400	2000
Feed Conveyor Hoods (4)	400	1600
Waste Hopper (1)	500	500
#6 Condenser for Reworkable Waste and Waste Machine (1)	4400	4400
Dust from the Card Room System	4000	<u>4000</u>
Total		32100

The last item above, "Dust from the Card Room System", provided an economic advantage by allowing the mill to upgrade the quality of the collected card room waste by diverting the dust to the lower quality waste collected in the opening and picking room.

This system was designed to clean up the visible lint and dust only. Since this was a relatively high quality operation, it was expected that minimum equipment and air quantities would be sufficient for the project objective of 0.5 mg/m³ on the vertical elutriator.

Duct, Filter and Return Air System. Please see the "Sampling Locations" drawing for a schematic layout of the duct and filter system. The opening and picking room was air conditioned and all of the air handled by the lint and dust control system was returned to the air conditioning apparatus room. And, from there it returned to the opening and picking area via the existing air conditioning return air duct.

The filter system was a continuous-automatic type consisting of a centrifugal lint preseparator followed by a rotary drum filter 7 ft. in diameter and 11 ft. long operating at a lower-than-standard 142 fpm face velocity. The suction stripper nozzle removed the collected dust from the face of the filter. This dust was directed to a No. 6 condenser in the waste room and the air from the No. 6 condenser was conveyed back to the rotary drum filter.

Summary of the Test Data.

OSHA General Area Samples (mg/m³) taken from 2/7/73 to 2/9/73. Before installation of the lint and dust control system.

n = 12	Minimum = 1.47
\bar{x} = 4.88	Median = 4.39
σ = 2.07	Maximum = 9.09

Vertical Elutriator Samples (mg/m³) taken from 2/7/73 to 2/9/73. Before installation of the lint and dust control system.

n = 6	Minimum = 1.47
\bar{x} = 1.70	Median = 1.70
σ = 0.14	Maximum = 1.86

Vertical Elutriator Samples (mg/m³) taken 5/2/73 to 5/4/73. After installation of lint and dust control system.

- Positions #1 and #3

n = 6	Minimum = 0.34
\bar{x} = 0.40	Median = 0.40
σ = 0.06	Maximum = 0.49

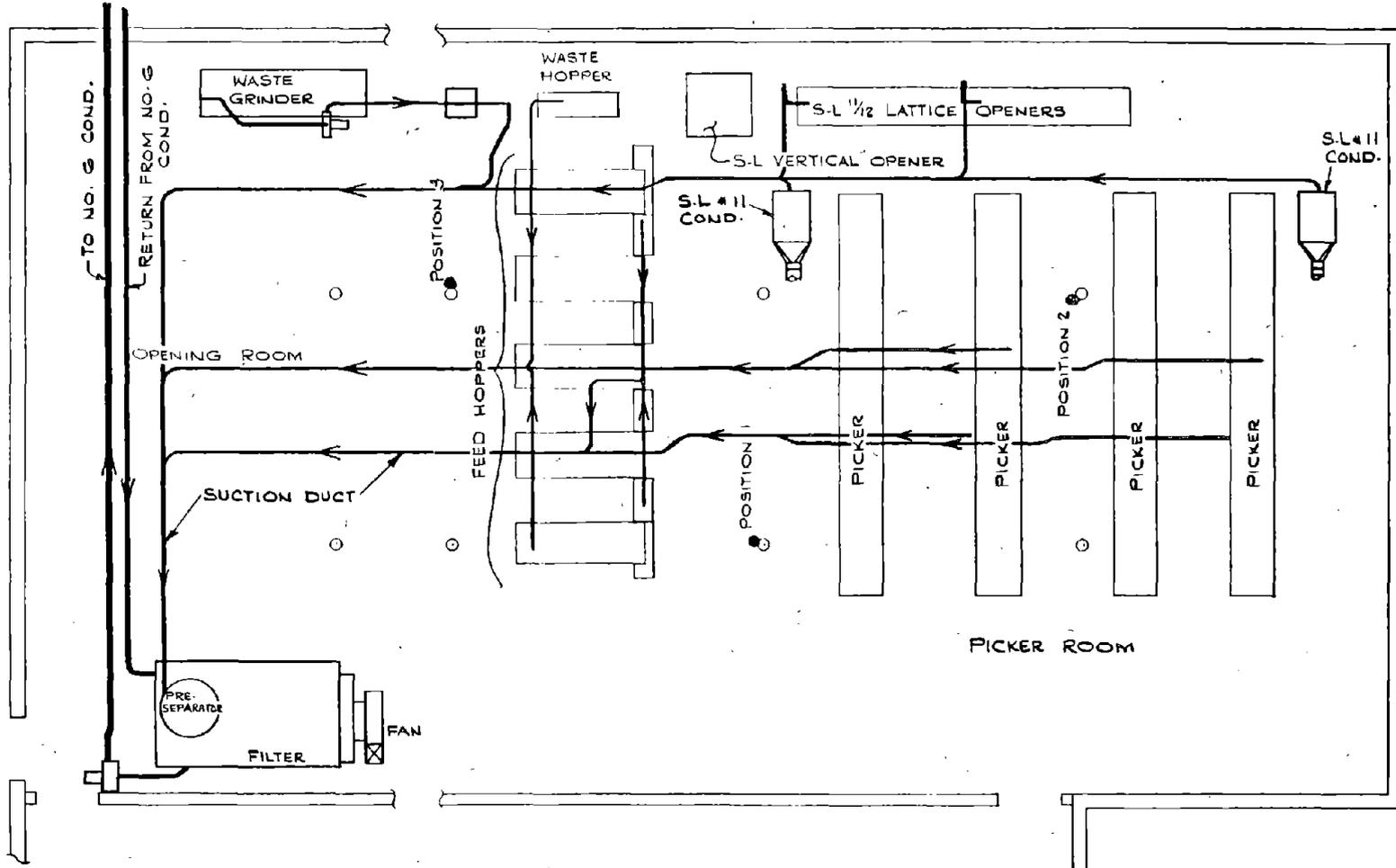
- Position #2. This elutriator was inadvertently mounted over the position where the operator manually cleans out motes and trash from under the grid bars of the picker beater. This operation was performed several times a shift and created a "cloud" of dust.

n = 3	Minimum = 0.52
\bar{x} = 0.61	Median = 0.57
σ = 0.12	Maximum = 0.75

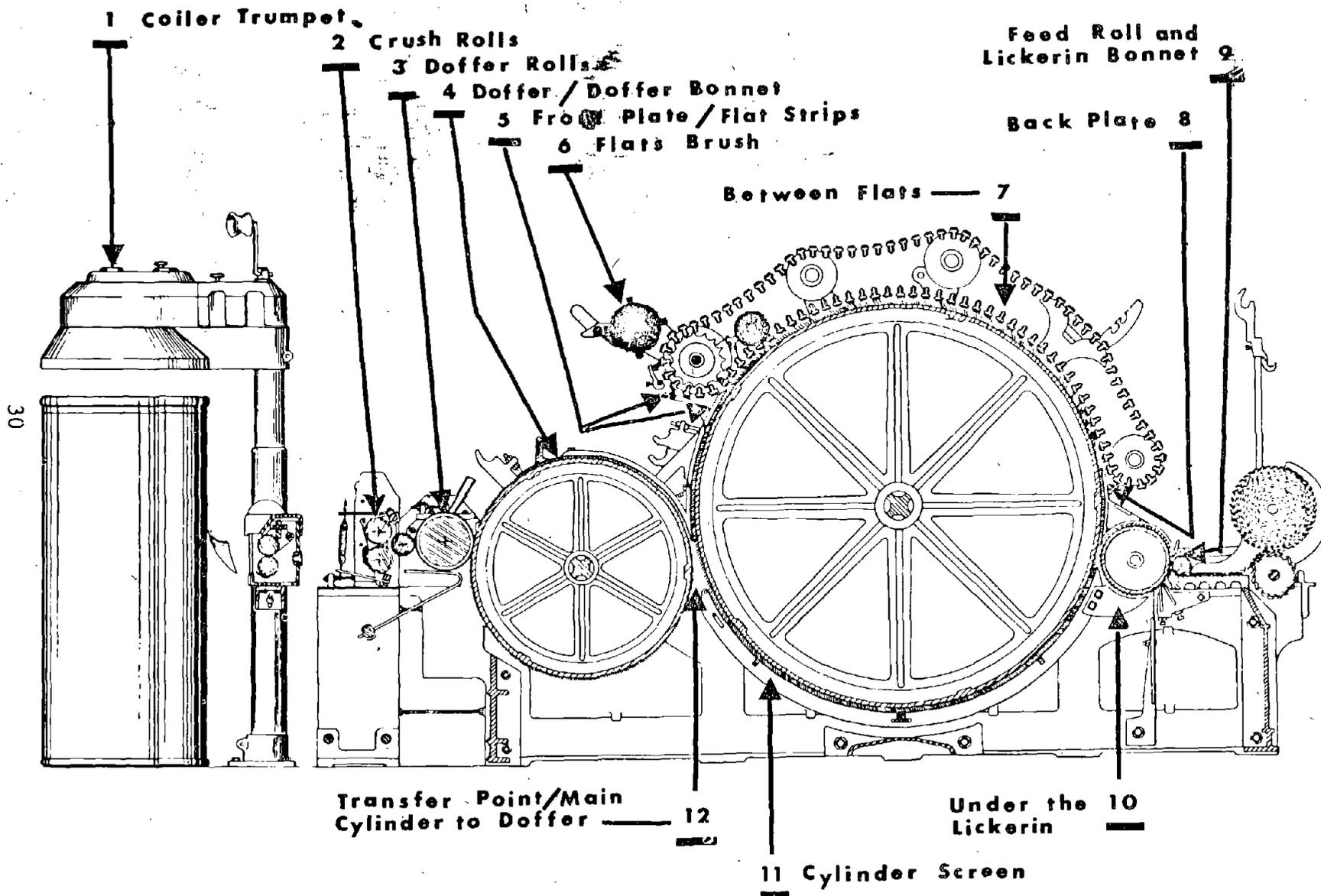
Comments and Conclusions. The data collected at positions #1 and #3 indicates that the production machinery emissions can be controlled by equipment as specified. The dust level could be lowered further by a second stage of the rotary drum filter plus some additions to the hooding and air quantities which might be required.

The data taken at position #2 raises a number of possibilities. First, the motes and trash which fall out under the grid bars of the picker beater could be collected automatically this eliminating the operator's exposure during manual cleaning. This would add considerably to the cost of such systems in picker rooms. If this waste is to be collected manually, then the operator should wear an approved respirator while performing this operation. This situation shows the difference between "engineering controls" and "administrative controls". In this situation there are engineering controls which automatically collect the lint and dust emitted by the production machinery into the working environment. For manual cleaning operations, it is obvious, then, that work habits must be controlled so that the operator does not expose himself to dust created by his own actions or personal protection should be used.

The OSHA General Area Samples reported here give some comparison between this instrument and the vertical elutriator in this given situation. OSHA General Area Samplers were not available to use along with the elutriators when taking samples after installation of the lint and dust control system.



MILL CODE 33 - OPENING & PICKING ROOM
SAMPLING LOCATIONS



MAJOR POINTS OF LINT & DUST GENERATION

Description
Lint and Dust Capture Devices for Cards

The preceding drawing indicates 12 points of lint, fly and dust generation. This does not pretend to number them all in detail but only to identify the significant areas. The bulk of this waste is, of course, generated in two places - (1) under the lickerin and (2) at the flats comb.

(1) Under the lickerin:

Unless there is excessive air pressure under the card this waste does not become airborne in the room and it is not a source of danger during normal operation.

If it is periodically removed manually the operator will be exposed to dust generated during this procedure. After the manual cleaning operation is completed any dangerous airborne dust should be captured by the dust control system on the card in a few minutes.

Most of the undercard waste can be collected continuously by the dust control system by adding an undercard plenum to the system. It is not generally done in American mills because of the added cost. However, on high speed plate-flats cards undercard suction is necessary to prevent excessive blowout of fine dust. At speeds above 60 lbs./hr. undercard suction may be necessary even on revolving flat top cards. Currently most cards operate at only 40 lbs./hr. or less.

(2) At the Flats Comb:

The flats strips are almost always collected by the dust control system because it costs nothing to do this. The air quantity and basic design of the dust capture device in this area are dictated by the problems of dust control. The flats strips can be collected by the same equipment.

The dust generated at the other 10 points shown on the card drawing becomes airborne if not captured at its source.

The minimum equipment required to control lint and dust generated by the card is a suction plenum over the lickerin and another over the doffer (with various attachments to extend the effectiveness of the moving air) plus a suction nozzle at the coiler trumpet. Such equipment on cards running up to 60 lbs./hr. and on any but the worst grades of stock will generally capture the dust well enough to control the dust level at less than 0.5 mg/m^3 on the vertical elutriator.

The lickerin plenum has a suction orifice in the front extending from side to side of the card which collects dust and fly from the top edge of the back plate and from between the flats. The back-flats shield extending up behind the flats protects the lap and the operators' hands from the flats clothing, helps to keep chunks of the lap from wedging between flats and back plate to damage the card or start a fire. It also is effective in controlling the dust escaping from between the flats across the top of the card. The orifice across the back edge of the lickerin plenum controls the emissions of fly and dust from under the bonnet and around the feed roll.

At the doffer end of the card the dust capture plenum is assisted by a brush shield which can be laid down out of the way and by a transparent web cover which can be raised for piecing up the web. There is a suction orifice across the front for controlling dust and fly around the doffer comb or take-off rolls and around the crush rolls and the web. Another suction orifice crosses the top of the plenum at its back edge to collect the flats strips, waste from the edge of the back plate and from the flats brush. The other drawing shows two orifices at the back of the plenum to draw air away from the juncture of doffer and cylinder and with it lint and fly that may cause screen chokes.

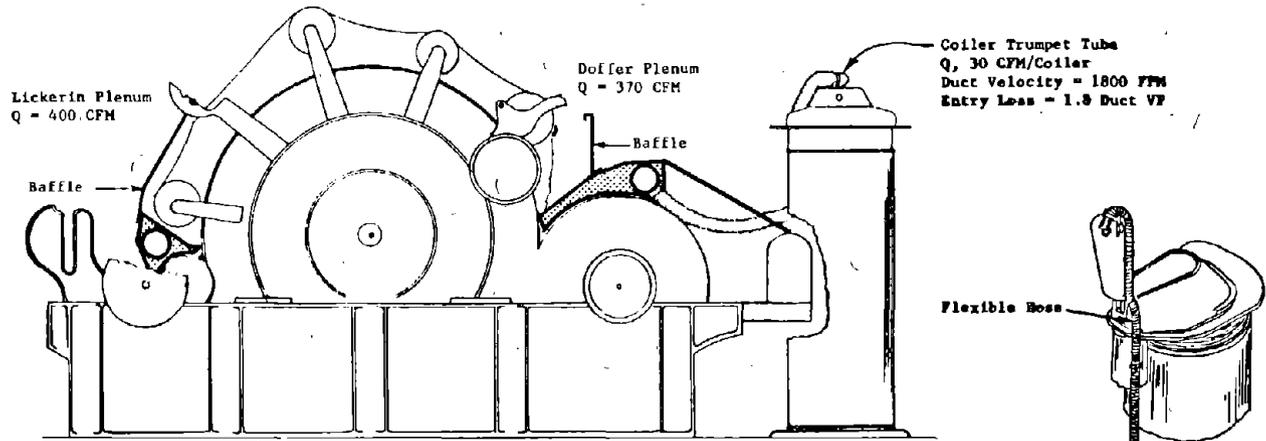
A minimum system should also include a simple suction nozzle at the coiler trumpet.

At extreme speeds control of the fine dust emitted across the top of the cylinder between the flats will require additional suction in that area. This is especially true if the flats are worn.

Air Quantity Requirements (cfm per Card)
Lint and Dust Control Systems for Cotton Cards
 (Cotton cards producing 40 lbs./hr. or less)

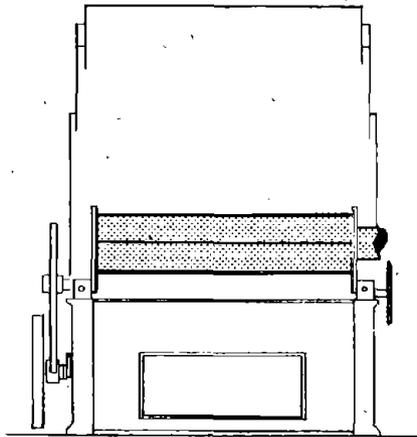
Doffer Plenum	372
Coiler Trumpet	31
Lickerin Plenum	<u>397</u>
Total	800
Undercard (optional)	<u>400</u>
Total	1200
Between Flats (optional)	<u>200</u>
Total	<u>1400</u>

Figures above are based on suction tubing connections at one side of the plenum. Air quantities can be increased up to 50% for special applications by attaching tubing at both sides of the plenum.

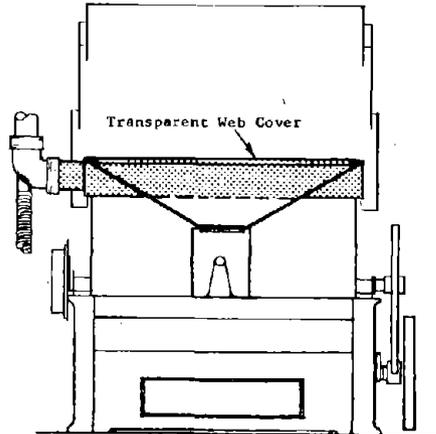


Side View of Card

Coiler Shown in Raised Position



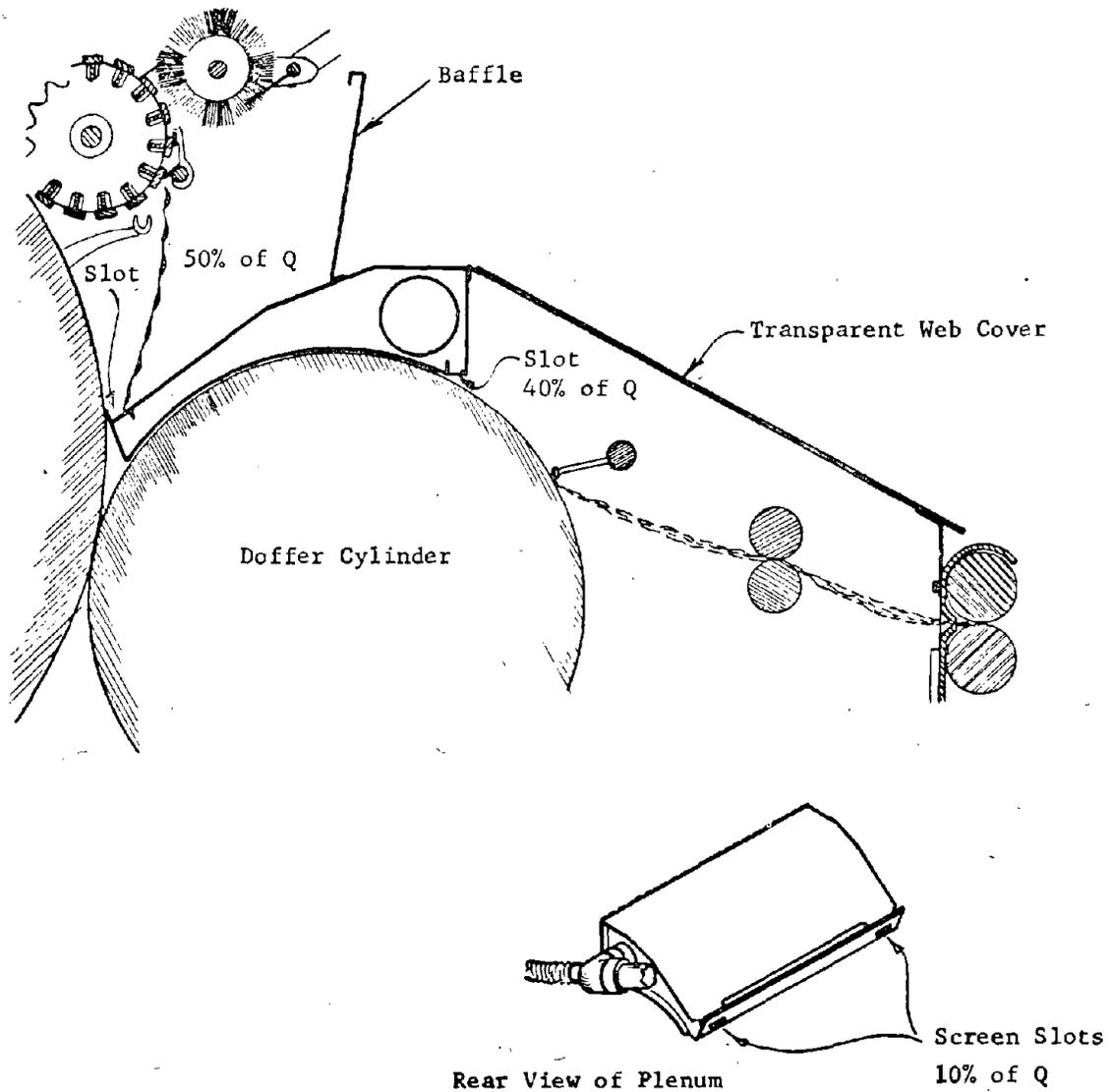
Rear View of Card



Front View of Card

SUCTION ATTACHMENTS FOR CARDS

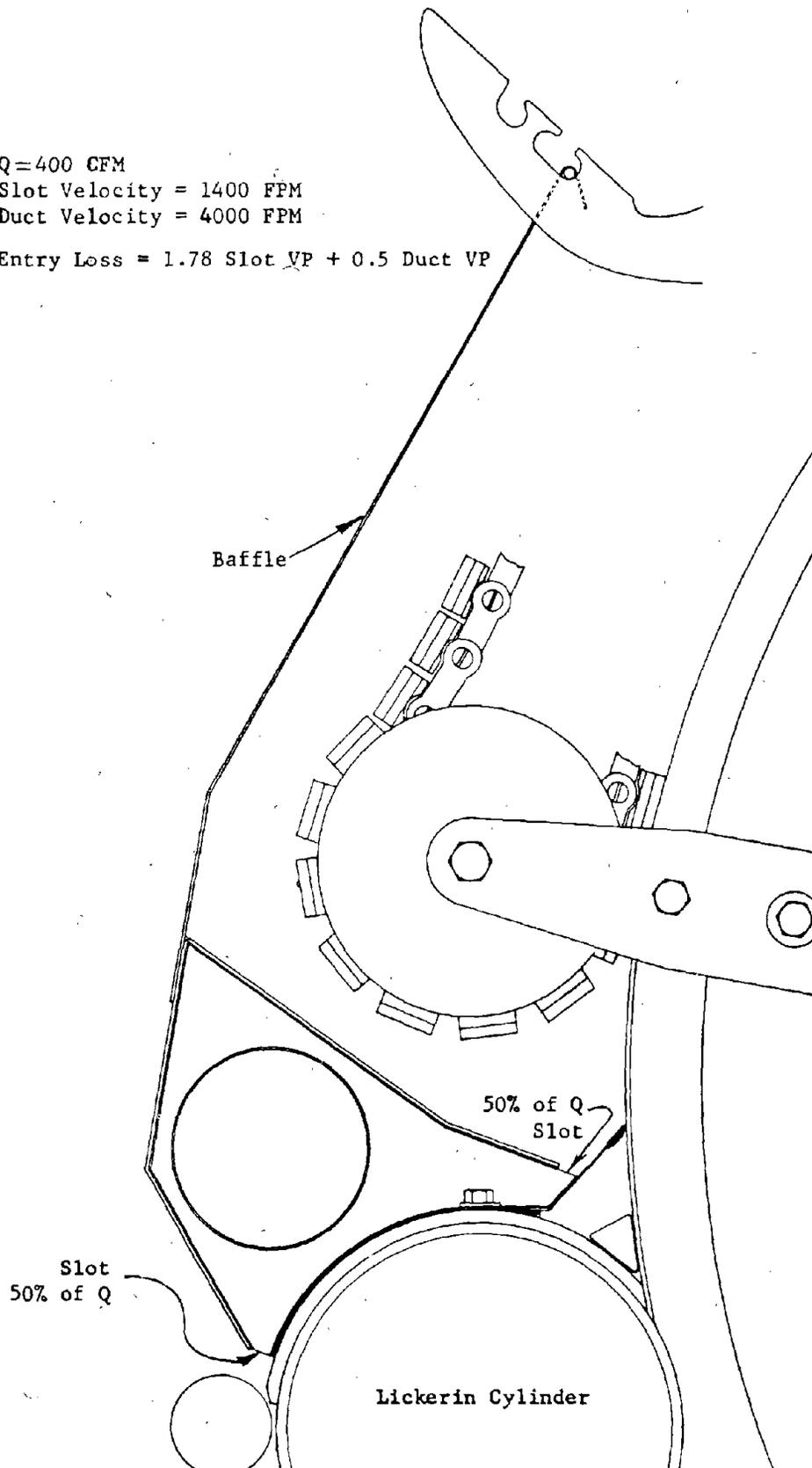
Q = 370 CFM
Slot Velocity = 700 FPM
Duct Velocity = 4000 FPM
Entry Loss = 1.78 Slot VP + 0.5 Duct VP



DOFFER PLENUM FOR CARDS

Q=400 CFM
Slot Velocity = 1400 FPM
Duct Velocity = 4000 FPM

Entry Loss = 1.78 Slot VP + 0.5 Duct VP



LICKERIN FENUM FOR CARDS

Dust Control System on Cards
at
Mill Code #8

Mill Code #8 manufactures fancy carded fabrics of 100% cotton, cotton and polyester blends, poplins, corduroys, oxfords and crepes. During the following tests the cotton was 1-1/16" staple strict low middling. Please refer to the "Sampler Locations" drawing which will show that during the testing system #1 was operating on 100% cotton, systems 2 and 3 were on a blend of 50% cotton and 50% polyester, and three cards were on 100% cotton, while system #5 was on 100% cotton.

Production Machinery Specifications and Arrangement. The cards in this mill were 40" Saco-Lowell rebuilt for high-speed production. They were equipped with metallic clothing and Crosrol Varga units. Production at the time of the testing on all cards was 40 lbs. per hour.

Please refer to the "Sampler Locations" drawing. There were 46 cards arranged in three lines of six cards on the sides with two lines of five cards in the center.

Lint and Dust Capture System. All of the 46 cards were equipped with suction attachments of a design which preceded those previously described. Please see the drawings which follow. An interesting difference between this and conventional installations is the fact that all of these cards were equipped with suction tubing at both ends of the plenums for maximum air quantity, and with an undercard suction plenum which collected the trash and fly falling out beneath the lickerin. A suction nozzle at the trumpet on the coiler completed the capture system. The unusually high air quantity distribution was as follows:

	<u>CFM</u>
Combination plenum, front of the card with brush shield, 3½" OD suction tubing at both sides of the card.....	512
Coiler trumpet nozzle, 2" OD suction tubing (coiler side only).....	48
Combination plenum, back of the card with back flats shield, 3½" OD suction tubing at both sides of the card.....	407
Undercard plenum with 4½" OD suction tubing at both sides of the card.....	<u>790</u>
Total.....	<u>1757</u>

This equipment was installed during the first half of 1970. It was designed to clean up the visible lint and dust only. Because of the high speed production rate of the cards, it was a difficult dust control problem.

Duct, Filter and Return Air System. The "Sampler Locations" drawing shows the general arrangement of the basic systems. There were five individual duct and filter systems. Four of these were of nine cards each, and one consisted of ten cards. This card room presented an excellent appearance because the ductwork was installed below the card room floor and hangs from the ceiling in the weave room below.

Each system consisted of a centrifugal lint preseparator which concentrated the lint into about 10% of the primary system air quantity, and a rotary drum filter in a sheet metal filter house which filtered the dust from the primary air stream. The concentrated material from the five preseparators was collected into one system and the material was further concentrated by a secondary preseparator into approximately 2,000 cfm. This air and the concentrated waste joined with the dust and the air from the rotary drum stripper systems for conveying to a disposition in the waste house. The conveying air from the secondary preseparator was reintroduced into four of the rotary drum filter houses so that any dust which might pass through the secondary preseparator would be filtered out before the air was released to the air conditioning system.

The collected material was ducted to the waste house where it was condensed into a mat form by passing through a Saco-Lowell No.6 condenser and deposited in a waste cart automatically. The air required for conveying the material to the waste house was only 4,500 cfm and could be "thrown away" at the waste house location. This was done by exhausting it into an enclosure with about 40 square feet of filter material to capture any dust escaping from the No. 6 condenser before it was released to atmosphere.

This card room was air conditioned to control both humidity and temperature. Dust control systems #2, 3, 4 and 5 returned through the air conditioning system. Dust control system #1 directly to the card room through an overhead discharge duct which is shown on the "Sampler Locations" drawing.

The filters on systems 2, 3, 4 and 5 were originally manually cleaned vee screens covered with 1/2" non-woven polyester filter media. These have been converted to continuous automatic rotary drum filters. The filter on system #1 was a new continuous-automatic rotary drum type. All of the filters drums were 5.5 ft. in diameter and about 6 feet long. Face velocity was from 160 to 200 fpm.

Summary of the Test Data. Sampler position #1 under influence of a direct room return from system #1 rotary drum filter handling nine cards. Six of these cards were equipped with chute feeds. Unfortunately, it was not, at that time, determined whether these feed systems were adding to the dust level in this area of the room. All of these cards were processing cotton.

High Vol Samples (mg/m³) taken from 10/11/71 to 10/19/71.

n = 16	Minimum = 0.77
\bar{x} = 1.71	Median = 1.69
σ = 0.53	Maximum = 2.69

Vertical Elutriator Samples (mg/m³) taken from 10/11/71 to 10/19/71.

n = 5	Minimum = 0.54
\bar{x} = 0.89	Median = 0.75
σ = 0.38	Maximum = 1.53

Sampler position #2 under influence of duct return from the air conditioning system. All cards around this position were processing blend of 50% cotton and 50% polyester fibers.

High Vol Samples (mg/m³) taken from 10/11/71 to 10/19/71.

n = 13	Minimum = 0.52
\bar{x} = 0.71	Median = 0.73
σ = 0.14	Maximum = 0.92

Vertical Elutriator Samples (mg/m³) taken from 10/11/71 to 10/19/71.

n = 6	Minimum = 0.12
\bar{x} = 0.29	Median = 0.30
σ = 0.09	Maximum = 0.40

Sampler position #3 under influence of duct return from the air conditioning system. All cards around this position were processing 100% cotton.

High Vol Samples (mg/m³) taken from 10/11/71 to 10/19/71.

n = 17	Minimum = 0.56
\bar{x} = 0.88	Median = 0.84
σ = 0.29	Maximum = 1.68

Vertical Elutriator Samples (mg/m³) taken from 10/11/71 to 10/19/71.

n = 6	Minimum = 0.40
\bar{x} = 0.51	Median = 0.43
σ = 0.15	Maximum = 0.70

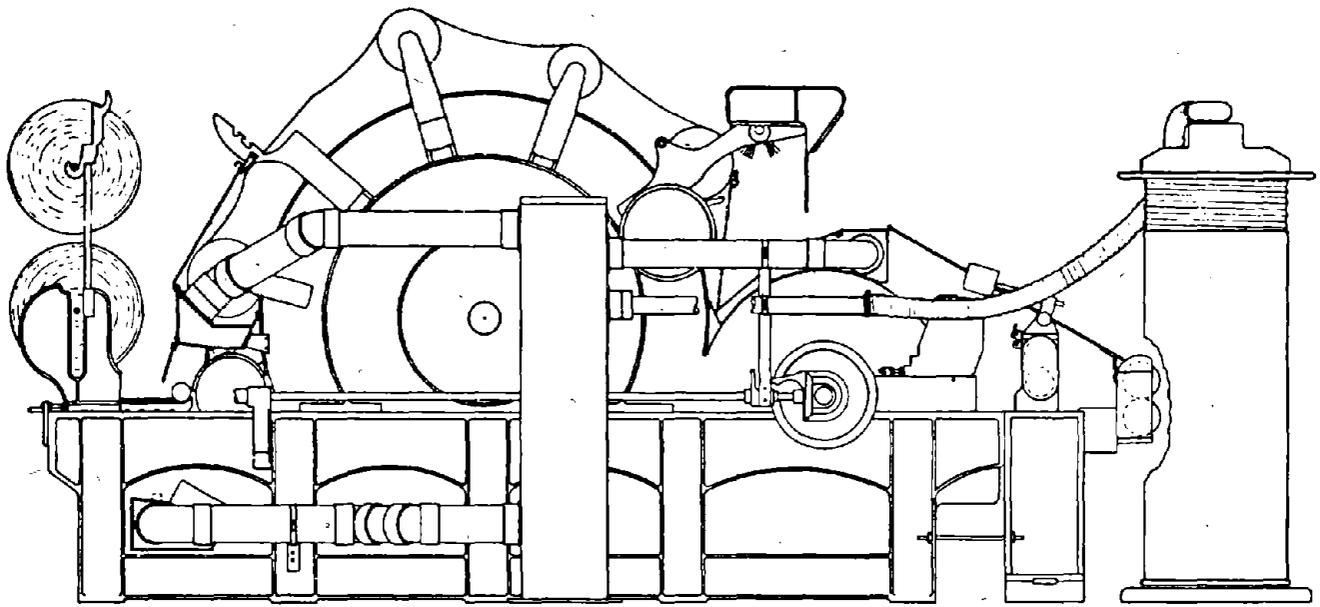
Comments and Conclusions. This study of the card room in Mill Code #8 was not reported here as an excellent example of cotton dust control, but rather as an example of the influence of control equipment specifications, system design and other variables of the cotton dust control problem. The most important features of this application were the undercard system and the very high air quantity. Without the undercard system, the air quantity per card would have been 967 cfm. Thus, the undercard system which added about 82% to the air quantity per card added something more than 100% to the dust control problem. Generally, the undercard waste will be about 50% of the total waste but the trash, coarse dust and fine dust content of the undercard waste is very high.

It is easier to control the fine dust level in a card room without undercard cleaning. This is to say that it requires less air quantity, less equipment, and, therefore, less money. However, automatic undercard cleaning reduces a dirty, manual job which if not accomplished by some manually controlled, high vacuum attachment will probably require the operator to wear an approved respirator. It is, therefore, an option which the mill operator must carefully consider (undercard suction is essential with plate flats or higher speeds).

The reader should not forget that this system was originally designed to control only the visible lint and dust. It accomplished that quite well and has been, in this respect, something of a model for the industry. It will be apparent from other reports on card rooms that the dust level as measured by the vertical elutriator in this room could be controlled to less than 0.5 mg/m^3 by the addition of more filtration. This could be accomplished by adding a second stage rotary drum filter to these systems and by adding a two-stage rotary drum filter between the secondary preseparator and the air conditioning system.

These data show the advantage of returning the air from a dust control system through good air conditioning filters. This also makes the point that additional filtration is required in a heavy dust load situation when returns through air conditioning filters are not practical. Finally, it should also be apparent that higher air quantity may not result in control of cotton dust to the desired level. These and other data show that filter specifications must be matched with increases in air quantity to make the combination of the two effective.

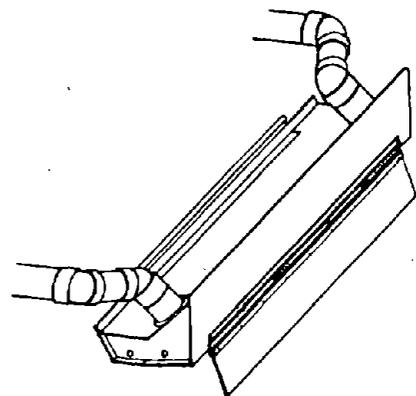
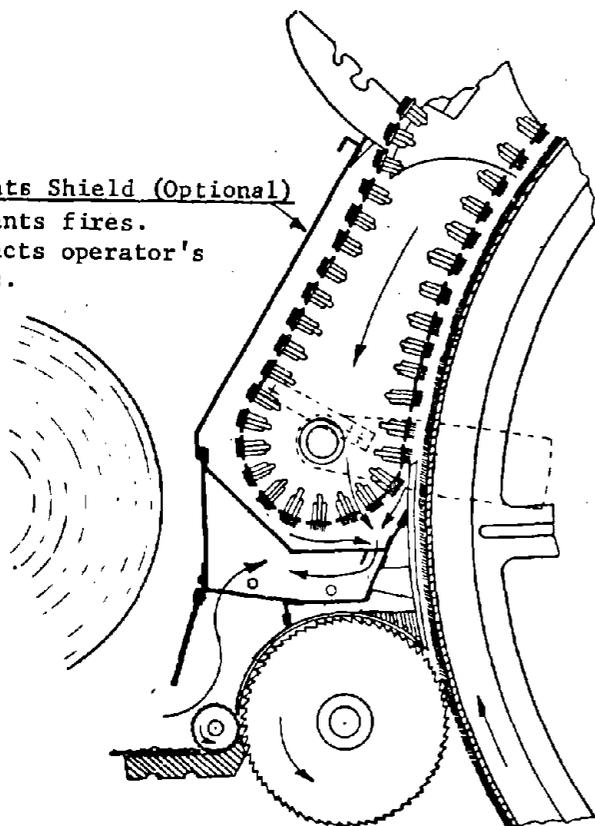
After writing the above, Shirley Analyzer data was received on the chute-feed stock processed on these cards indicating visible foreign matter of 2.5%, invisible loss of 0.4% for a total of 2.9%.



- CENTRAL SYSTEM
Underfloor Duct - Riser on Coiler Side

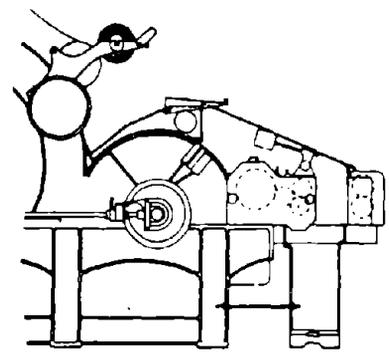
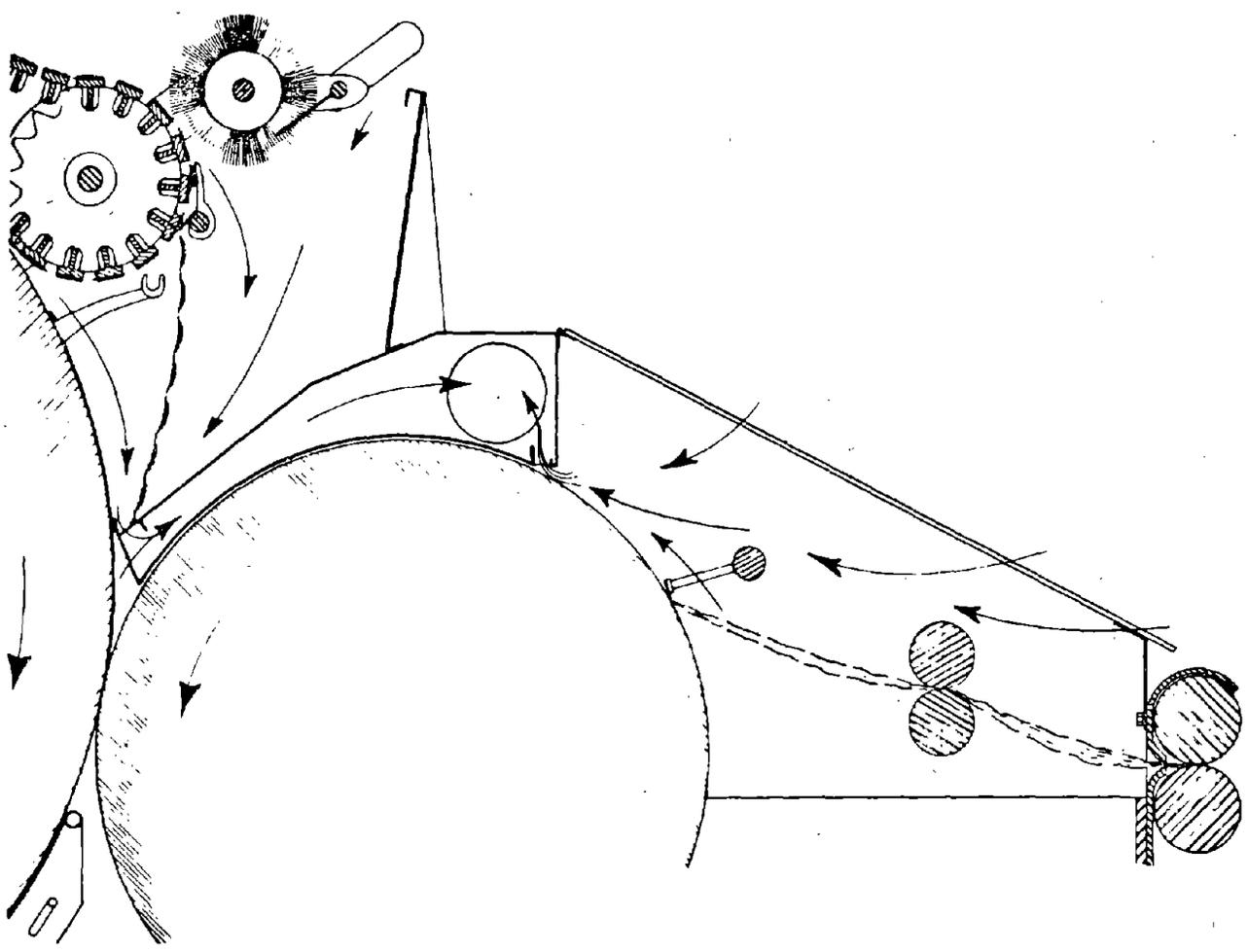
Back Flats Shield (Optional)

- Prevents fires.
- Protects operator's hands.



Combination Plenum - Back of the Card

- Functional air flow patterns.
- Note two orifice locations.
- Can be used with or without scavenger roll.

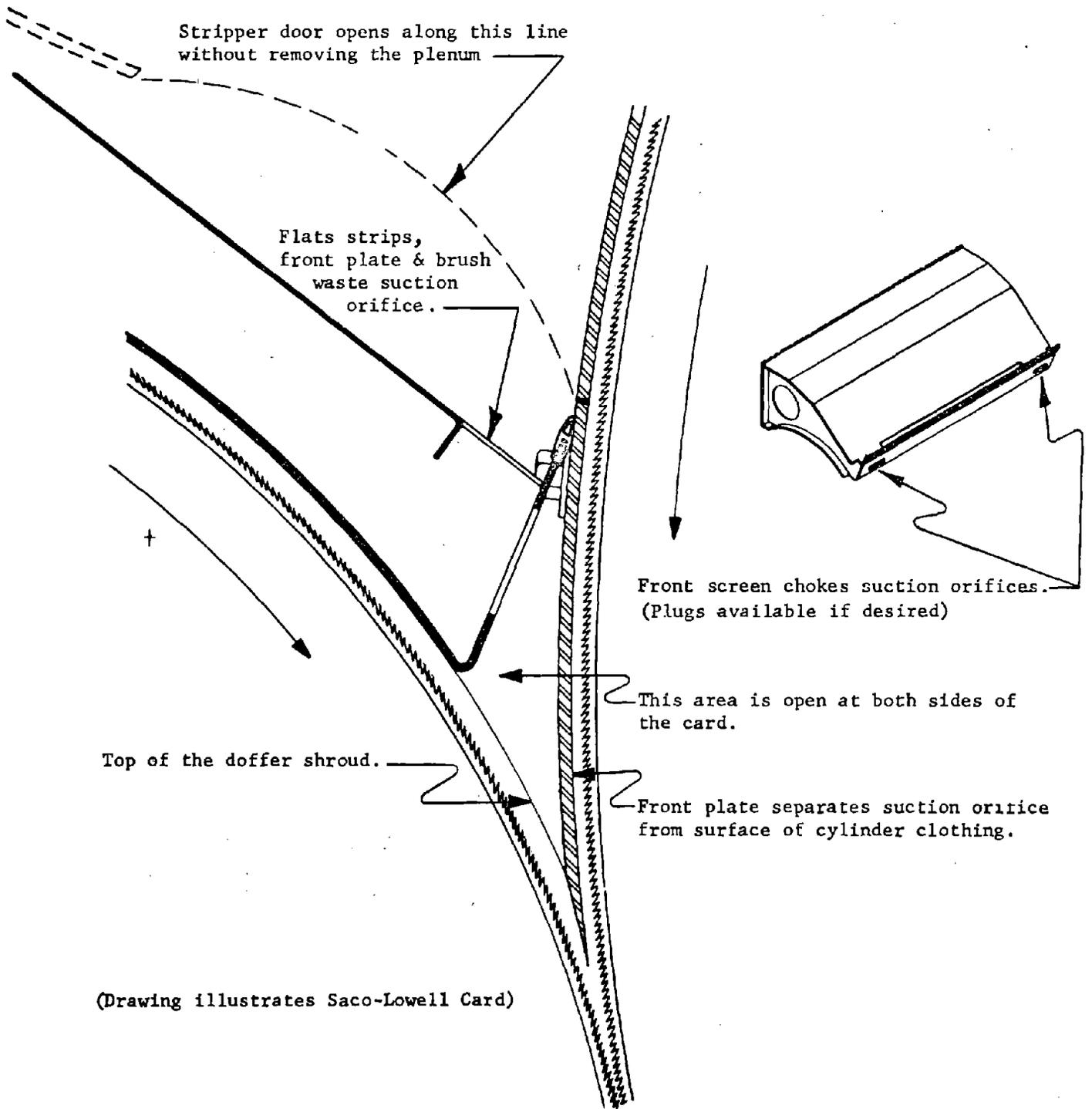


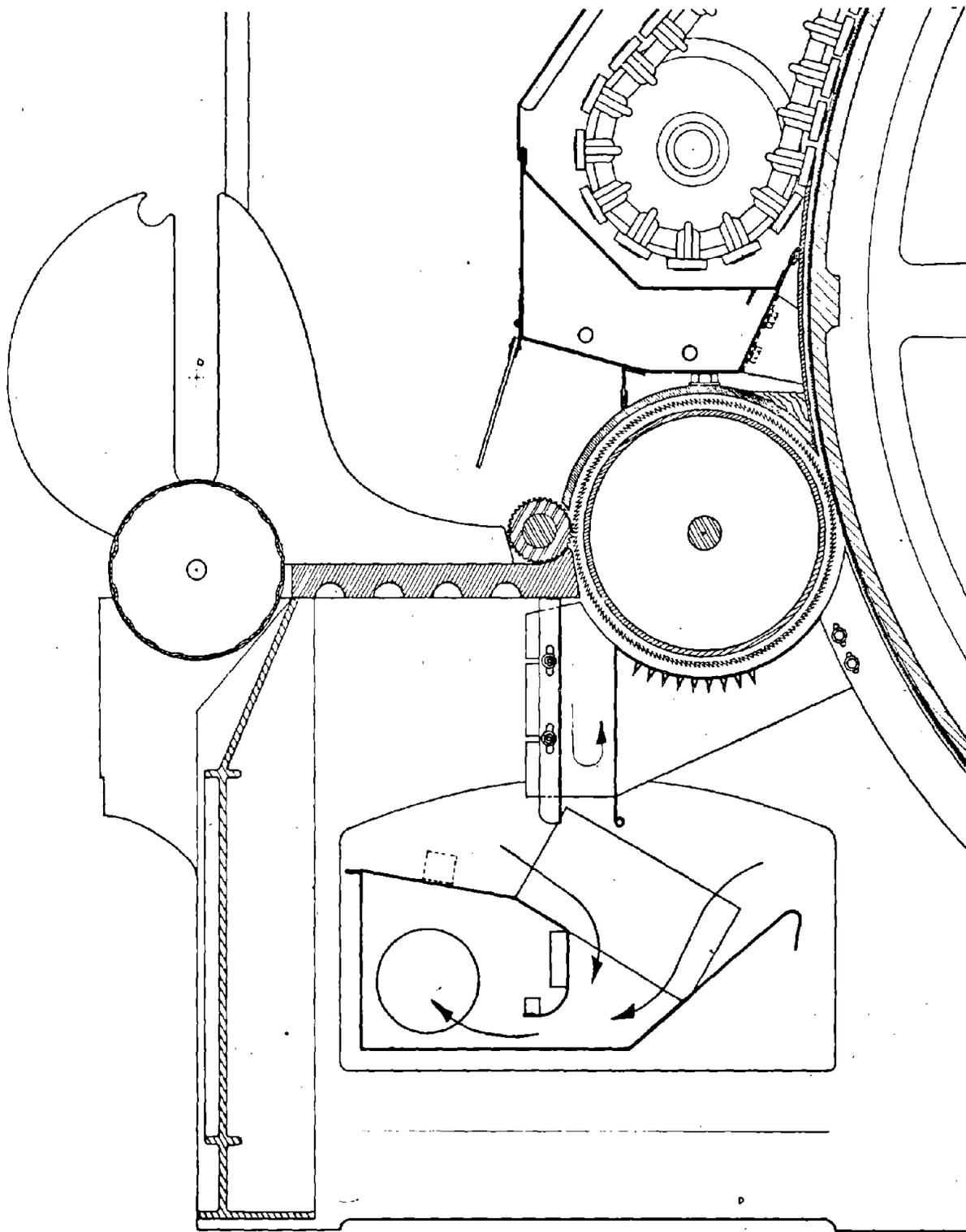
With Brush Shield Lowered

Combination Plenum - Front of the Card

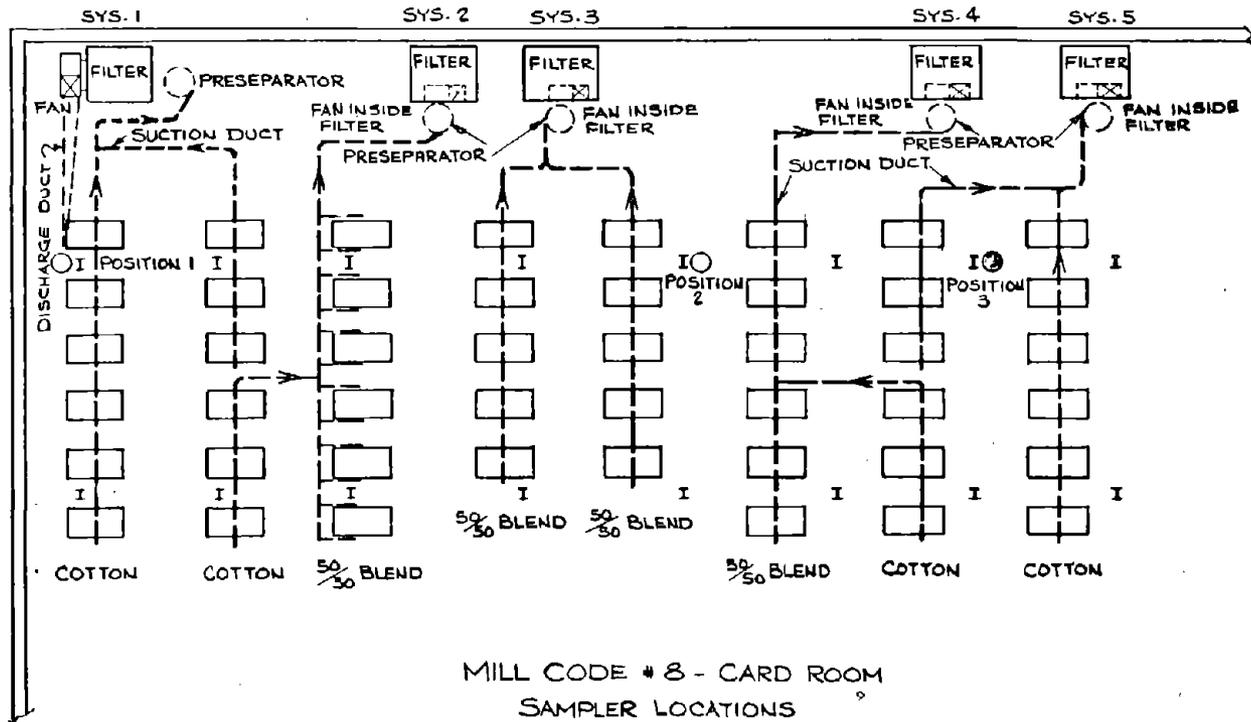
- Functional air flow patterns with brush shield.
- Note three suction orifice locations.

COMBINATION PLENUM - FRONT OF THE CARD
Cylinder/Doffer Transfer Point - Front Screen Choke Cleaning





Undercard Plenum with Fiber Retriever
(Shown with Combination Lickerin Plenum)
43



Dust Control System on Cards
at
Mill Code #13

Mill Code #13 manufactures combed and carded yarns of cotton and cotton/synthetic blends in counts of 14's and 40's. The stock being processed during the test was 1-1/16" middling cotton.

Production Machinery Specifications and Arrangement. The cards were rebuilt and modernized Saco-Lowell, Whitin Model "L" and Whitin New "H". They were equipped with metallic clothing and 77 were equipped with doffer combs and Abington crush rolls. These cards were producing at the rate of 18 lbs. per hour. There were 6 cards running at 35 lbs. per hour which were equipped with Gunter & Cooke roller takeoff and crush rolls.

Please refer to the two "Sampler Locations" drawings. There were 83 cards total arranged in 7 rows.

Lint and Dust Capture System. All of the 83 cards were equipped with suction attachments in a modified arrangement #6M of a design which preceded those previously described. Drawings of the plenums are shown in the report, "Dust Control System on Cards at Mill Code #8". The reader should note that all of the plenums shown there were not used at Mill Code #13. Suction plenums specifications and air quantities are as follows:

	<u>CFM</u>
Combination plenum, front of the card with brush shield, 3-1/4" OD suction tubing, both sides (short-turn elbows)	395
Coiler trumpet cleaning, 1.9" OD suction tubing on the coiler side	38
Combination plenum, back of the card with back flats shield, 3-1/4" OD suction tubing, both sides (short-turn elbows)	<u>387</u>
Total	820

This equipment was installed during the first half of 1971 and was specified to control the visible lint and dust only.

Duct, Filter and Return Air System. The two "Sampler Locations" drawings show a layout of the card room machinery and the primary duct systems. See also the "Schematic Layout" which shows how the systems were interconnected with one another and with the air conditioning system. System #1 handled 35 cards. The lint waste was separated by the preseparator which also received the lint waste from system #2 along with 10% of the primary air quantity of system #2. The preseparator on system #1, therefore, handled all of the collected lint waste for the total 83 cards. This lint waste was concentrated into 10% of the primary air stream of system #1 and conveyed to the No. 6 condenser. The No. 6 condenser deposited the collected waste into a suitable waste-handling cart and the air from the No. 6 was recirculated through the rotary drum filter on system #1. The filter on system #1 was 7 ft. in diameter by 7 ft. long and was handling all of the air from 35 cards plus 10% of the air quantity of system #2, plus 400 cfm from the stripper nozzle on the system #2 filter. This totals 33,000 cfm for a face velocity of approximately 229 fpm. The air from system #1 was returned directly to the room through overhead ductwork and four-way deflection grills.

Duct, Filter and Return Air System. (continued)

System #2 handled 48 cards. The lint waste was separated by the preseparator. All of this waste was ducted to the entry side of the preseparator on system #1. The rotary drum filter on system #2 was 7 ft. in diameter by 7 ft. long and was handling 35,000 cfm at a face velocity of approximately 242 fpm. The fan on system #2 returned all of the dust control system air to the air conditioning apparatus room. This air was returned to the card room by the air conditioning supply-air ductwork.

This card room was air conditioned for control of both humidity and temperature. The air conditioning system handled approximately 54,000 cfm. This was greater than the air quantity returned to the apparatus room by the lint and dust control system. The additional air required to meet the demand of the air conditioning system entered the apparatus room through a saran vee screen as shown on the "Sampler Locations" drawing for system #2. There were no additional filters upstream of the washer.

Summary of the Test Data.

Sampler position #1. Samples taken between 9/17/71 and 9/24/71.

		High-Vol <u>mg/m³</u>	Vertical Elutriator <u>mg/m³</u>
n	=	8	5
\bar{x}	=	0.73	0.44
σ	=	0.12	0.09
Minimum	=	0.53	0.33
Median	=	0.74	0.48
Maximum	=	0.86	0.52

Sampler position #2. Samples taken between 9/17/71 and 9/24/71.

		High-Vol <u>mg/m³</u>	Vertical Elutriator <u>mg/m³</u>
n	=	9	5
\bar{x}	=	0.91	0.50
σ	=	0.12	0.09
Minimum	=	0.70	0.38
Median	=	0.95	0.53
Maximum	=	1.07	0.58

Sampler position #3. Samples taken between 9/17/71 and 9/24/71.

		High-Vol <u>mg/m³</u>	Vertical Elutriator <u>mg/m³</u>
n	=	8	5
\bar{x}	=	1.49	0.42
σ	=	0.32	0.08
Minimum	=	1.09	0.29
Median	=	1.39	0.44
Maximum	=	1.97	0.50

Summary of the Test Data. (continued)

Sampler position #1. Samples taken between 10/25/71 and 10/29/71. Vertical elutriator samples (mg/m³)

n	=	5	Minimum	=	0.41
\bar{x}	=	0.45	Median	=	0.44
σ	=	0.04	Maximum	=	0.52

Sampler position #4. Samples taken between 10/25/71 and 10/29/71.

		High-Vol mg/m ³	Vertical Elutriator mg/m ³
n	=	19	5
\bar{x}	=	0.97	0.50
σ	=	0.20	0.04
Minimum	=	0.73	0.45
Median	=	0.93	0.50
Maximum	=	1.66	0.55

Sampler position #5 (in the duct returning air from the filter on system #1). Samples taken from 10/25/71 to 10/29/71. High-Vol samples (mg/m³).

n	=	7	Minimum	=	0.69
\bar{x}	=	1.00	Median	=	0.97
σ	=	0.27	Maximum	=	1.55

Sampler positions 1, 2, 3 and 4. All measurements shown above combined.

		High-Vol mg/m ³	Vertical Elutriator mg/m ³
n	=	44	25
\bar{x}	=	1.01	0.46
σ	=	0.31	0.07
Minimum	=	0.53	0.29
Median	=	0.94	0.47
Maximum	=	1.97	0.58

Comments and Conclusions. Although the maximum dust levels* in this card room did exceed 0.5 mg/m³, this study was included in this report because it was a large card room in which a number of interesting influences were at work. First, there were two systems. Second, the air drawn from the room by both the air conditioning system and the dust control system on the cards was pulling the air supplied to the drawing, combing and roving areas to and across portions of the card room. This brought with it the lint, fly and dust created by those machines. Third, system #1 received and handled all of the lint waste and dust separated by the preseparator on system #2 as well as the dust recirculated to its rotary drum filter from the No. 6 condenser. Fourth, the air exhausted from the system #1 filter was returned to the system #1 area of the card room without other filtration.

With all of these factors involved, it is somewhat surprising that there is so little variation in the following figures:

* - As measured by the vertical elutriator.

Comments and Conclusions. (continued)

<u>Sampler Position</u>	<u>High Vol</u>	<u>Vertical Elutriator</u>	<u>% Fine Dust (VE/HV)</u>
1	0.73	0.44	60.3
2	0.91	0.50	54.9
3	1.49	0.42	28.2
4	.97	0.50	51.5
5	1.00	--	--

The sampler at position #1 might have been under some influence of the air returning from the system #1 filter, but it would appear to have been under almost no influence from the drawing, combing and roving machinery. This seems to be borne out by the relatively low readings of both the high-vol and vertical elutriator samplers with a high percentage of fine dust which would be expected from the cards.

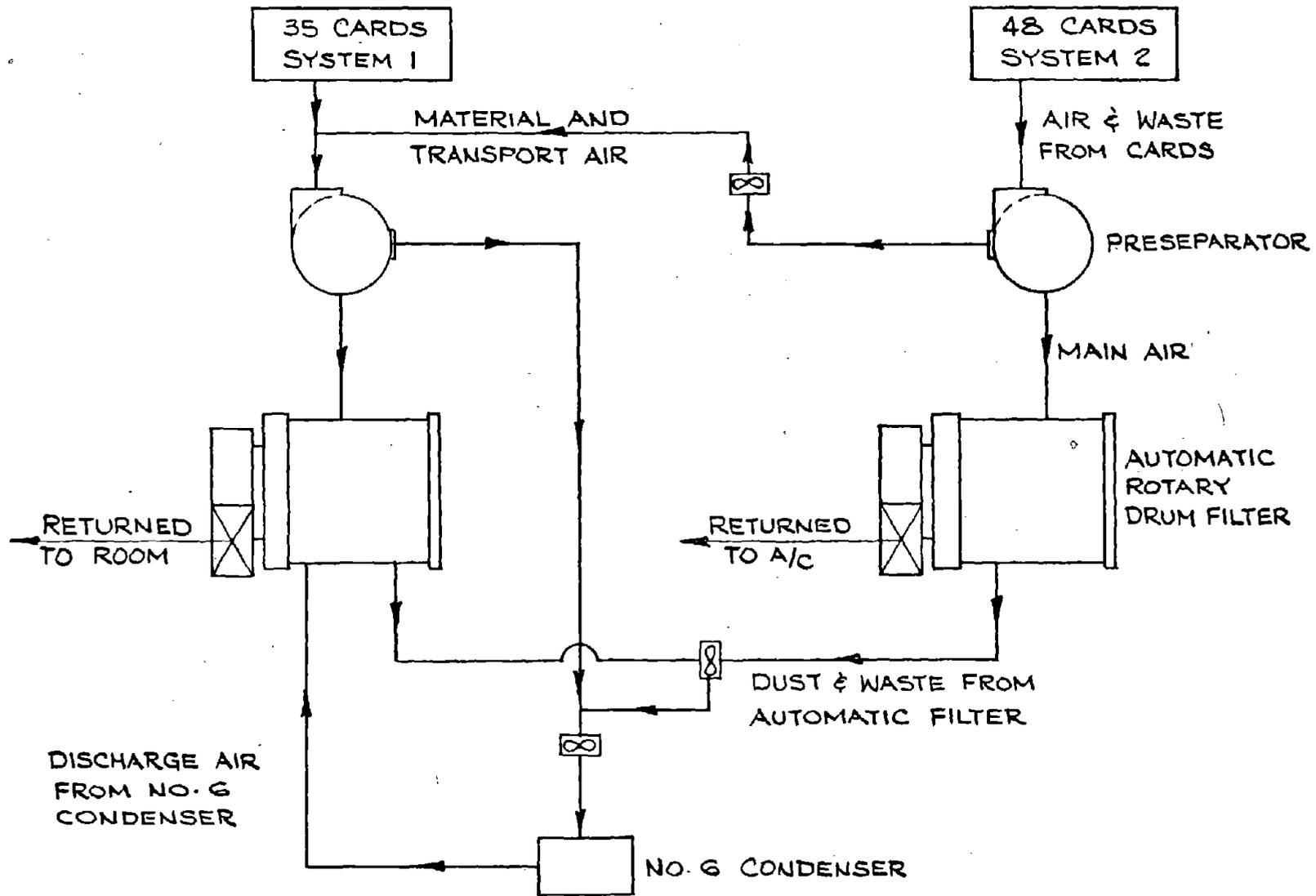
Sampler position #2 was adjacent to the drawing, combing and roving area but should not have been under any influence from the air returned to the room from the filter in system #1. It was obviously receiving both fly and dust from the drawing, combing and roving area in addition to that which could be expected in the carding area.

Position #3 was also adjacent to the drawing, combing and roving area. The figures indicate that it was receiving a considerable amount of fly from those machines. This is indicated by the very high level measured on the high-vol sampler and the low measurement taken by the vertical elutriator in the same position.

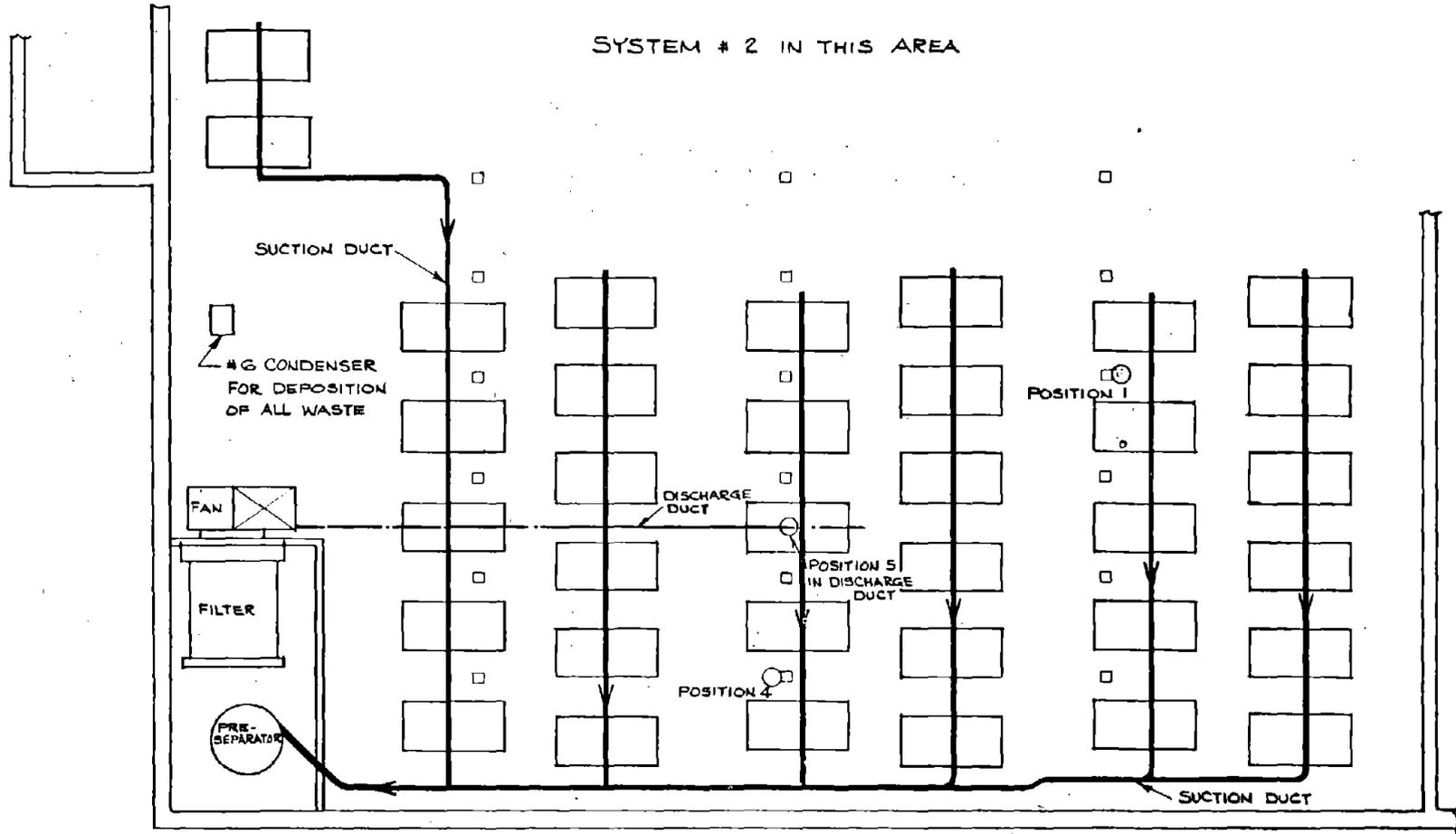
Sampler position #4 was under direct influence of the air returned to the room from the filter in system #1. This filter which was specified to control the visible lint and dust only was doing a better job than might be expected considering the excessive dust load that it was handling.

Sampler position #5 measured the dust level in the air being discharged into the room from the filter in system #1. It is interesting to note how closely this measurement of the total dust in the duct compares to the total dust measurement at position #4. As a matter of fact, it may be more interesting to compare this measurement to the high-vol levels in positions #1, 2 and 3, while comparing the vertical elutriator measurements at position #4 with those other positions.

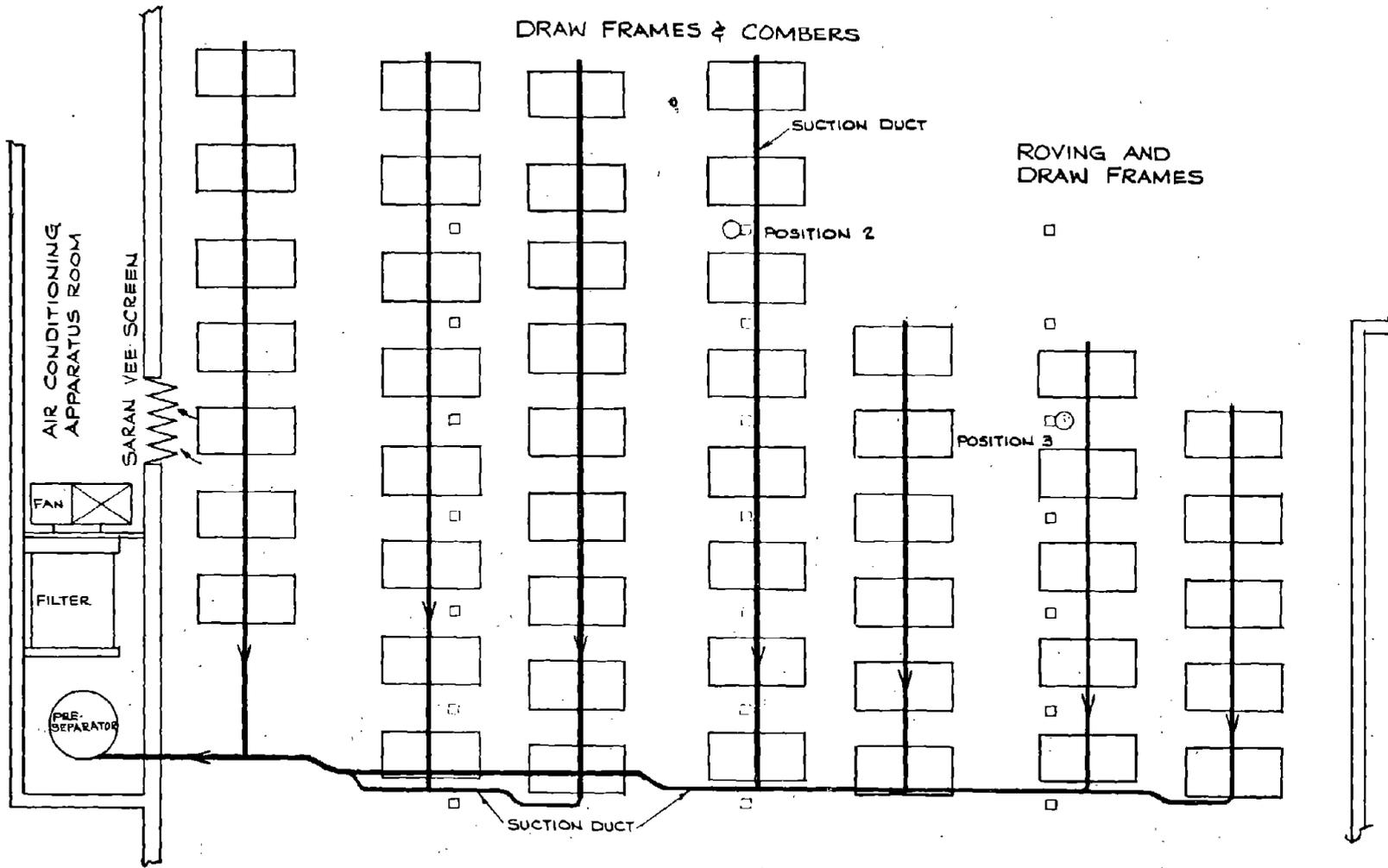
The maximum vertical elutriator levels at positions #1, 2, 3, and 4 could probably be reduced to less than 0.5 mg/m^3 by an increase in the efficiency of the filters. This could be accomplished by increasing the size of these units or by the use of two-stage filters. It would, of course, be desirable in this mill to equip the drawing, combing and roving machines with a central lint and dust filter system.



Mill Code #13 - Card Room - Schematic



MILL CODE #13 - CARD ROOM - SYSTEM #1
SAMPLER LOCATIONS



MILL CODE # 13 - CARD ROOM - SYSTEM 2
SAMPLER LOCATIONS

Dust Control System on Cards
at
Mill Code #14

Mill Code #14 manufactures combed Peeler cotton weaving and knitting yarns in counts of 16's to 60's. At the time of testing the stock was 1-1/8" staple strict middling cotton.

Production Machinery Specifications and Arrangement. The cards in this mill were Whitin Model L and Whitin Model New H which have been reworked and modernized. They were equipped with metallic clothing, Hollingsworth doffer take-off, Trash-masher crush rolls, individual drives and 24" x 48" coilers. They were operating at a production rate of 24 lbs. per hour during all of the study.

Please refer to the "Sampler Locations" drawing which shows a total of 40 cards arranged in three rows across the card room.

Lint and Dust Capture System. These cards were all equipped with suction plenums previously described. The equipment used at Mill #14 is described as arrangement Al6M. Equipment specifications and air quantities are as follows:

	<u>CFM</u>
Combination plenum, front of the card with brush shield, 4½" OD suction tubing on the coiler side.....	372
Coiler trumper cleaning, 1.9" OD suction tubing into 4½" elbow on the coiler side.....	31
Lickerin plenum with back flats shield type B1, 4½" OD suction tubing on the coiler side.....	397
Total.....	800

This equipment was installed during the last half of 1971. It was designed to clean up the visible lint and dust only.

Duct, Filter and Return Air System. The "Sampler Locations" drawing shows that there was one filter system for the 40 cards handling a total of 32,000 cfm with one fan and two preseparators. Each preseparator handled 20 cards. The lint waste from the preseparators was ducted to a No. 6 condenser where the lint was deposited in a waste cart. The air from the condenser was returned to the upstream side of the rotary drum filter.

This card room was air conditioned to control both humidity and temperature. All of the air handled by the lint and dust control system was ducted to the air conditioning apparatus room. From thence it was returned to the card room through the air conditioning supply air duct system (vee screens with non-woven media in front of the washers).

Summary of the Test Data.

High Vol Samples (mg/m^3) taken from 9/28/71 to 10/5/71 at positions 1, 2 and 3 before installation of the lint and dust control system.

n =	57	Minimum =	5.18
\bar{x} =	11.01	Median =	10.69
σ =	3.22	Maximum =	21.2

Vertical Elutriator Samples (mg/m^3) taken from 9/8/71 to 10/15/71 at positions 1, 2 and 3 before installation of the lint and dust control system.

n =	19	Minimum =	2.32
\bar{x} =	3.03	Median =	2.81
σ =	0.69	Maximum =	5.39

High Vol Samples (mg/m^3) taken from 11/4/71 to 11/12/71 at positions 2 and 3 after installation of the lint and dust control system.

n =	52	Minimum =	0.51
\bar{x} =	0.86	Median =	0.86
σ =	0.20	Maximum =	1.50

Vertical Elutriator Samples (mg/m^3) taken from 11/4/71 to 11/12/71 at positions 2 and 3 after installation of the lint and dust control system.

n =	26	Minimum =	0.26
\bar{x} =	0.40	Median =	0.38
σ =	0.14	Maximum =	0.80

High Vol Samples (mg/m^3) taken from 11/4/71 to 11/12/71 at position 1 after installation of the lint and dust control system.

n =	18	Minimum =	1.54
\bar{x} =	3.20	Median =	2.97
σ =	1.10	Maximum =	6.93

Vertical Elutriator Samples (mg/m^3) taken from 11/4/71 to 11/12/71 at position 6 after installation of the lint and dust control system.

$n =$	9	Minimum =	0.74
$\bar{x} =$	1.19	Median =	1.20
$\sigma =$	0.20	Maximum =	1.49

High Vol Samples (mg/m^3) taken from 11/4/71 to 11/12/71 at position 6 after installation of the lint and dust control system.

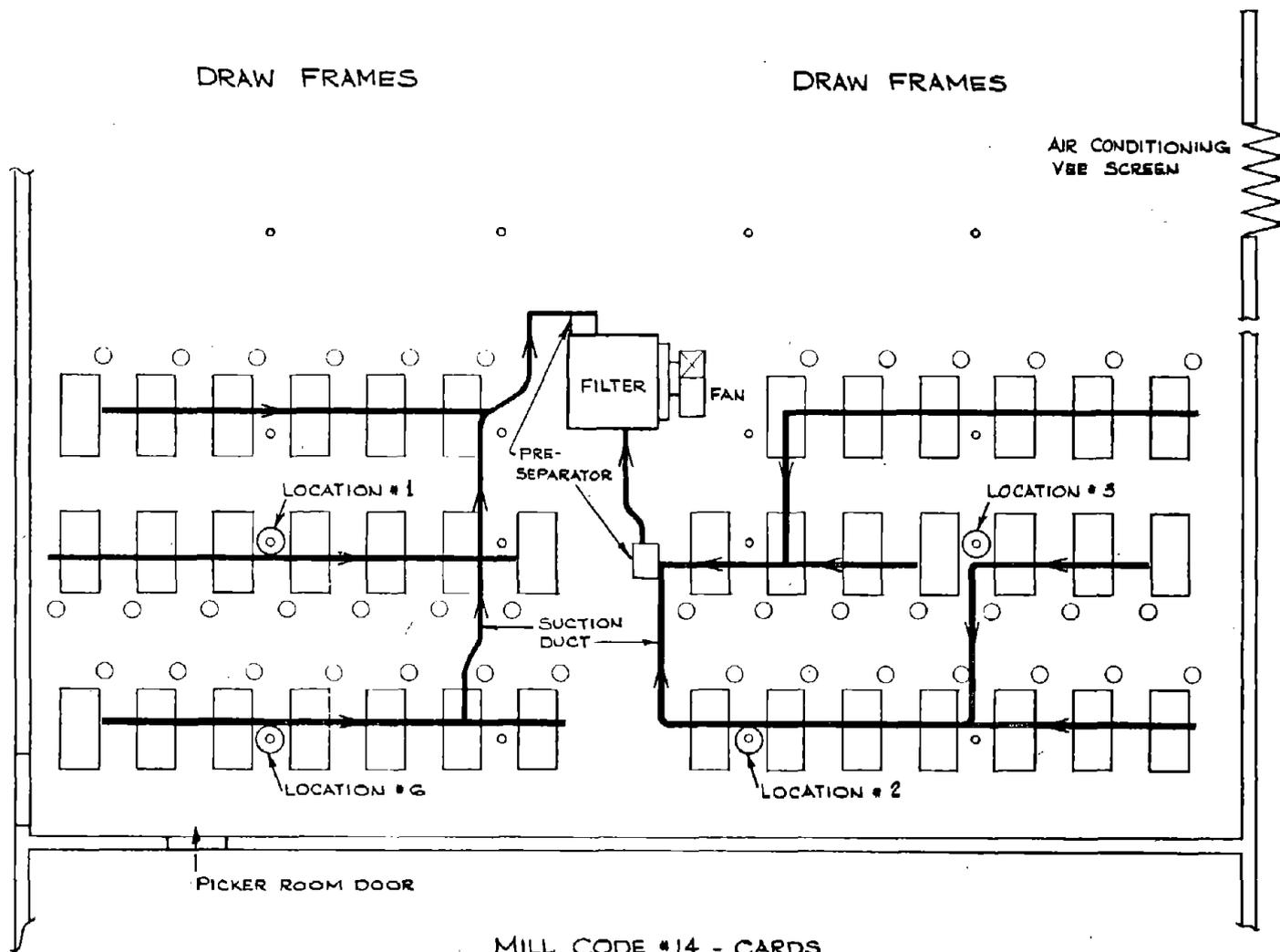
$n =$	8	Minimum =	0.53
$\bar{x} =$	1.10	Median =	1.04
$\sigma =$	0.43	Maximum =	1.96

Comments and Conclusions. This study of the card room at Mill Code #14 is not included in this report as an example of correct specifications for control of the dust level to $0.5 \text{ mg}/\text{m}^3$ as measured with the vertical elutriator. This mill is, rather, a sample of one of the studies which was made to determine how to specify the systems so that they would pass a dust level standard - or rather, how to predict the resulting dust level in the working area. It was an extended test comprising samples.

This study teaches a number of useful things:

1. This was not an easy dust control problem as shown by the high vol and vertical elutriator samples taken before the dust control system was installed. However, the dust control system which was designed to control only the visible lint and dust did show that in some places it brought the dust level down to a figure less than the current OSHA standard of $1.0 \text{ mg}/\text{m}^3$ with most of the vertical elutriator readings less than $0.4 \text{ mg}/\text{m}^3$.
2. After the dust control system was installed, measurements at location 1 as compared to locations 2 and 3 showed that the dust level was badly out of balance. The equipment layout was quite uniform and the dust level also should have been uniform. It was obvious that location 1 was under influence from some other source of dust.
3. It was obvious after a little study that the contamination which was unbalancing the dust level in the card room came from the picker room. This occurred because the picker room was air conditioned by the same system that air conditioned the card room. However, there was no dust control system in the picker room and no return to the air conditioning system except through the card

room. Additional readings were therefore taken near the picker room door at location #6. This confirmed the heavy contamination which was entering the card room from the picker room door but it did indicate that location 1 was probably under more influence of this flow than location #6. It can be concluded that the dust from the picker room was actually affecting all of the readings in the card room to some degree.



DRAW FRAMES

DRAW FRAMES

AIR CONDITIONING
VBE SCREEN

FILTER

FAN

PRE-SEPARATOR

SUCTION
DUCT

LOCATION #1

LOCATION #3

LOCATION #6

LOCATION #2

PICKER ROOM DOOR

MILL CODE #14 - CARDS
SAMPLER LOCATIONS

Dust Control System on Cards
at
Mill Code #19

Mill Code #19 manufactures corduroy and some denim yarns from 100% cotton stock. Specifications on the raw cotton were not available but the Shirley Analyzer data on stock delivered to the cards from the chute feeds showed 1.9% visible foreign matter, 0.6% invisible loss for a total of 2.5%.

Production Machinery Specifications and Arrangement. This was one of the most modern card rooms in the industry. The cards were Saco-Lowell's, rebuilt for high speed production, equipped with metallic clothing, individual drives and Crosrol Varga units. They were fed by CMC chute feeders with the material being brought to the feeders from the opening room via Fiber Control systems. These high speed cards were producing 65 lbs. per hour of 63 grains per yard sliver.

Please refer to the "Sampler Locations" drawing. There were a total of 26 cards in this operation. Fourteen of these were in one room in two lines of seven cards. In another room were two lines of six cards. In the open area between the cards four No. 6/7 condensers were taking air from the CMC transport lines. These No. 6/7 units were maintained much better than is customary in operations of this kind. There was a waste feeder and two condensers that brought stock from the opening and cleaning room to the card room. The air from these units returned to 6/7 filters in the basement and therefore did not affect the dust level in the card room.

Lint and Dust Capture System. This card room presented an excellent appearance because all of the dust control system ductwork and the filters were located in the room below the card room. All of the 26 cards were equipped with suction plenums as previously described in Arrangement #A16C. Air quantities were as follows:

	<u>CFM</u>
Combination plenum with flats brush shield, front of the card, 4½" OD	
suction tubing on the coiler side	372
Coiler trumpet cleaning, 1.9" OD	
suction tubing, coiler side	31
Lickerin plenum, 3½" OD suction tubing on both sides	<u>397</u>
Total	800

This equipment was installed during the first half of 1972. The high speed of the cards and the stock being processed indicated a difficult dust control problem. However, the system was specified to control the visible lint and dust only.

Duct, Filter and Return Air System. The "Sampler Locations" drawing shows a schematic layout of the underfloor duct collecting lint and dust from all of the 26 cards. The lint was taken out by a centrifugal preseparator and the collected waste was deposited in a bin by a No. 6 condenser located near the filter. Air from the No. 6 condenser was recycled to the filter. The dust filter was a continuous-automatic rotary drum type, 5.5 ft. in diameter and 6 ft. long, handling 20,800 cfm at a face velocity of 216 fpm. The stripper nozzle air was recycled through the No. 6 condenser and back to the "dirty" side of the filter.

Duct, Filter and Return Air System. (continued)

This card room was air conditioned for both humidity and temperature control, and all of the air from the lint and dust control system was discharged into the air conditioning apparatus room. Upstream of the washer was an automatic, flat, deep-media filter through which all of the air from the lint and dust control system passed before entering the washer and returning to the card room through the regular air conditioning supply ductwork.

These card rooms were also affected by an interesting "over-aired" situation. The large room receives approximately 16,358 cfm over-supply of air conditioned air, (above the air quantity returned to the air conditioning system from this room). The smaller room receives an over supply of approximately 4,355 cfm of conditioned air. Such an "over-aired" condition would tend to "flush out" the area involved and decrease the dust level in the card rooms.

Summary of the Test Data.

OSHA General Area Samples (mg/m³) taken 5/7/73.

Position #1 = 0.53
Position #2 = 0.48
Position #3 = 0.71

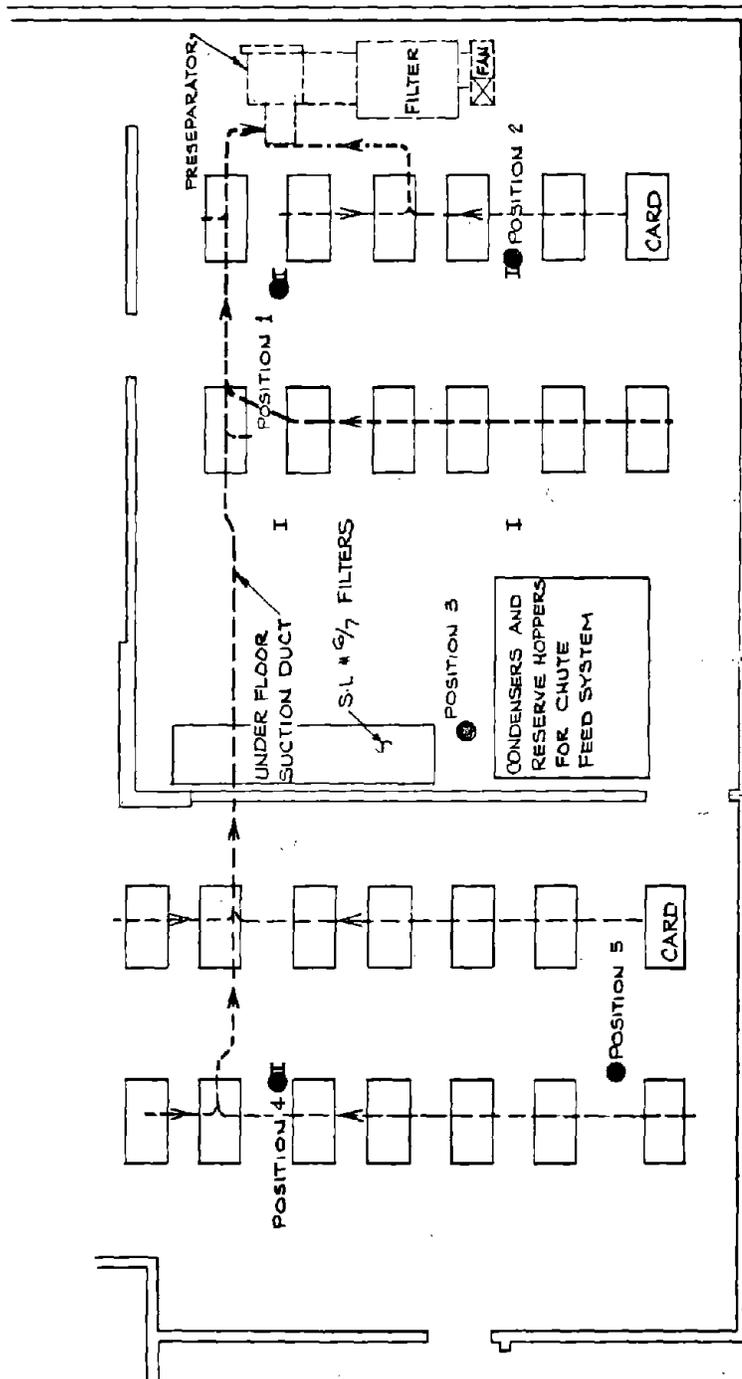
Vertical Elutriator Samples (mg/m³) taken from 5/8/73 to 5/11/73
at positions 1, 2, 4 and 5.

n = 15 Minimum = 0.17
 \bar{x} = 0.23 Median = 0.21
 σ = 0.05 Maximum = 0.33

Comments and Conclusions. The dust levels measured in these card rooms are better than expected. This excellent performance is attributed to:

1. The excellent cotton cleaning job apparently accomplished by the cleaning equipment.
2. Excellent condition of the CMC feeders and the cards. All of this equipment was obviously adjusted for top efficiency and it is becoming obvious that this contributes a great deal to the efficiency of dust control systems.
3. The surplus air supply from the air conditioning system flushes some of the dust out of the area.

To appreciate the results of this study, the reader should not forget that these cards were producing 65 lbs. per hour from low-grade 100% cotton stock and the lint and dust control system was handling the standard minimum 800 cfm per card.



MILL CODE 19 - CARD ROOM
SAMPLER LOCATIONS

Dust Control System on Opening and Carding Processes
at
Mill Code #34

Mill Code #34 manufactures towels from 100% low middling cotton of 1-1/32" staple.

Production Machinery Specifications and Arrangement. The appearance, operation, and obvious production efficiency make this one of the most impressive modern installations in the industry. The cards were Whitin Model "H", rebuilt for high-speed production, equipped with metallic clothing, individual drives and Crosrol Varga units. They were fed by CMC Chute Feeders with stock brought from typical opening and cleaning equipment by Fiber Control fans. These high-speed cards are producing a 65 grain sliver at the rate of 70 lbs. per hour.

Please refer to the "Sampler Locations" drawing. There were a total of 18 cards arranged in two rows of 9 cards each. Opening and cleaning equipment was located in an adjacent but separate room.

Lint and Dust Capture System. The cards were equipped with suction plenums as previously described in a modified arrangement #A16C. Dust control air quantities for both the carding and opening areas were as follows:

<u>Cards</u>	<u>cfm</u>
Combination plenum with flats brush shield, front of the card, 4½" OD suction tubing on the coiler side	388
Top calender roll cleaning, 1.9" OD suction tubing into 4½" elbow on the coiler side	15
Lickerin plenum type B, with back flats shield, 3½" OD suction tubing on both sides	397
Total	800
 <u>CMC Chute Feeds</u>	
Discharge at each card	800
Per Card Total, Card and CMC	1,600
 <u>Opening and Cleaning</u>	
4 #11 condensers @ 3000	12,000
10 hoppers @ 600	6,000
Total opening and cleaning	18,000

This equipment was installed during the first half of 1972. The high speed of the cards and the stock being processed indicate a difficult dust control problem. However, the system was specified to clean up the visible lint and dust only.

Duct, Filter and Return Air Systems. The "Sampler Locations" drawing shows the general layout of the suction duct. There were two complete systems, one for carding and another for the opening room. The "Filter System Schematic" drawing shows the interesting integration of the two systems for optimum control and quality of the collected waste. The dust control system in each room was of the continuous-automatic type featured in most of the studies for this project. Each system included a centrifugal lint waste separator upstream of automatic rotary drum

Duct, Filter and Return Air Systems. (continued)

filters. The system for the card room which was operating on 18 cards was designed for 20 cards. It was designed, therefore, for an air quantity of 33,100 cfm to be handled by a filter 7 ft. in diameter and 8 ft. long operating at approximately 205 fpm. The filter on the opening room system was handling approximately 19,000 cfm through a filter 5.5 ft. in diameter and 6 ft. long, operating at approximately 197 fpm face velocity.

Both of these production rooms were air conditioned for control of both humidity and temperature. All of the air exhausted by both of the dust control systems was returned to the room by way of the air conditioning apparatus and return duct system. Vee cell filters with 3/4" nonwoven polyester media were installed upstream of the washer.

Summary of the Test Data.

Card Room

Vertical Elutriator Samples (mg/m³)

<u>Date</u>	<u>Position #1</u>	<u>Position #2</u>
5/7/73	0.36	0.30
5/8/73	0.34	0.33
5/9/73	0.32	0.36
5/10/73	0.31	0.37
n = 8	Minimum = 0.30	
\bar{x} = 0.34	Median = 0.34	
σ = 0.03	Maximum = 0.37	

Opening Room

Vertical Elutriator Samples (mg/m³)

<u>Date</u>	<u>Position #3</u>	<u>Position #4</u>
5/7/73	0.25	0.21
5/8/73	0.28	0.25
5/9/73	0.38	0.53
5/10/73	0.25	0.23
n = 8	Minimum = 0.21	
\bar{x} = 0.30	Median = 0.25	
σ = 0.11	Maximum = 0.53	

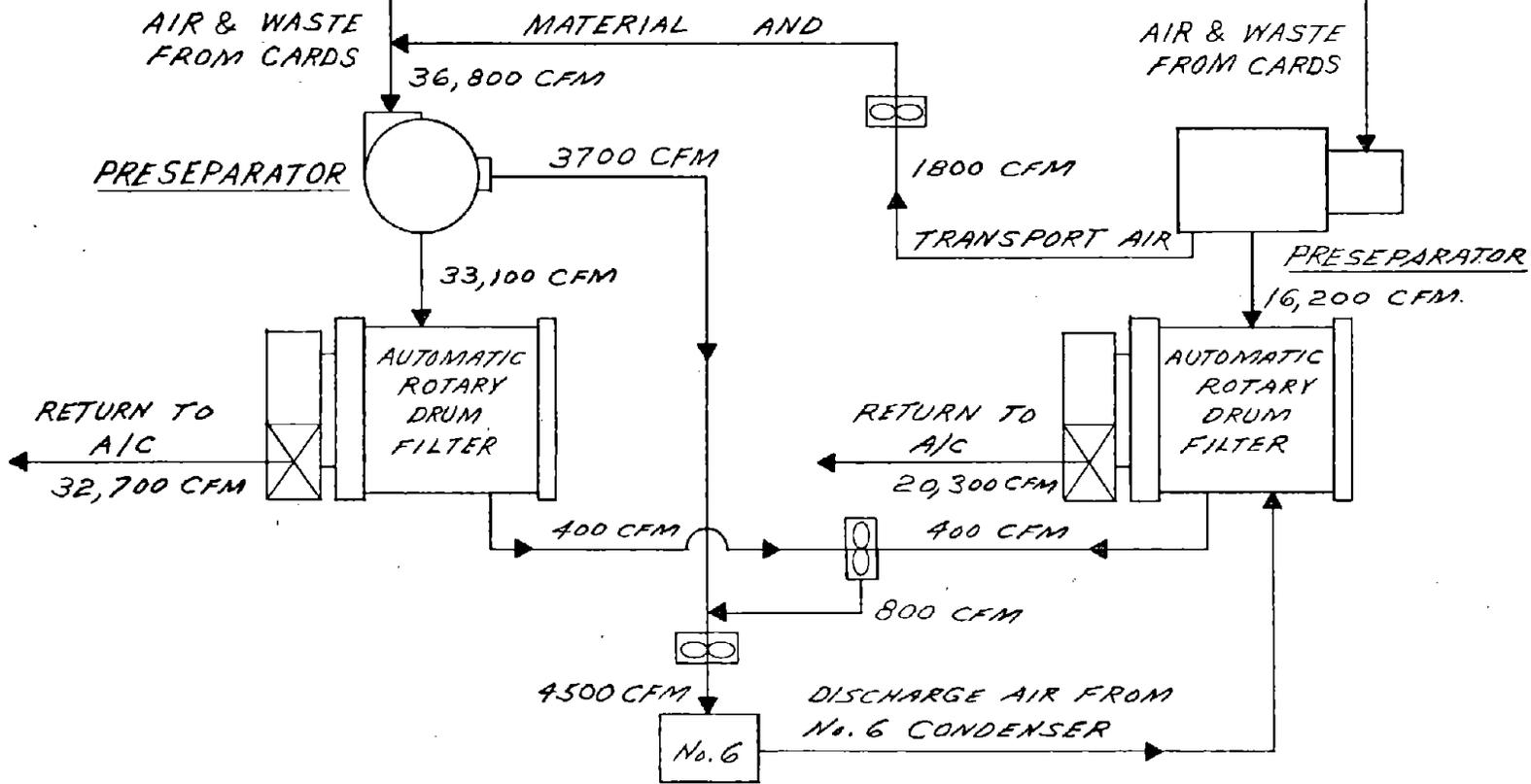
Although not observed at the time, it was obvious that something out of the ordinary affected the reading at position #4 in the opening room on May 9. If this sample, which is more than twice as high as the other 3, is excluded, the summary becomes:

n = 7	Minimum = 0.21
\bar{x} = 0.26	Median = 0.25
σ = 0.06	Maximum = 0.38

Comments and Conclusions. Considering the fact that these cards were operating at 70 lbs. per hour production on a relatively low grade of cotton, it was a pleasant surprise to find dust concentrations controlled to such a low level by a system of minimum specification designed to control only the visible lint and dust. This excellent performance can be credited in some large degree to the excellence of the textile processing operations and machinery. It is an outstanding example of good planning, modern machinery and good operating procedures. Unfortunately, the dust control system designer must never expect and seldom enjoys the benefit of such a combination of favorable factors.

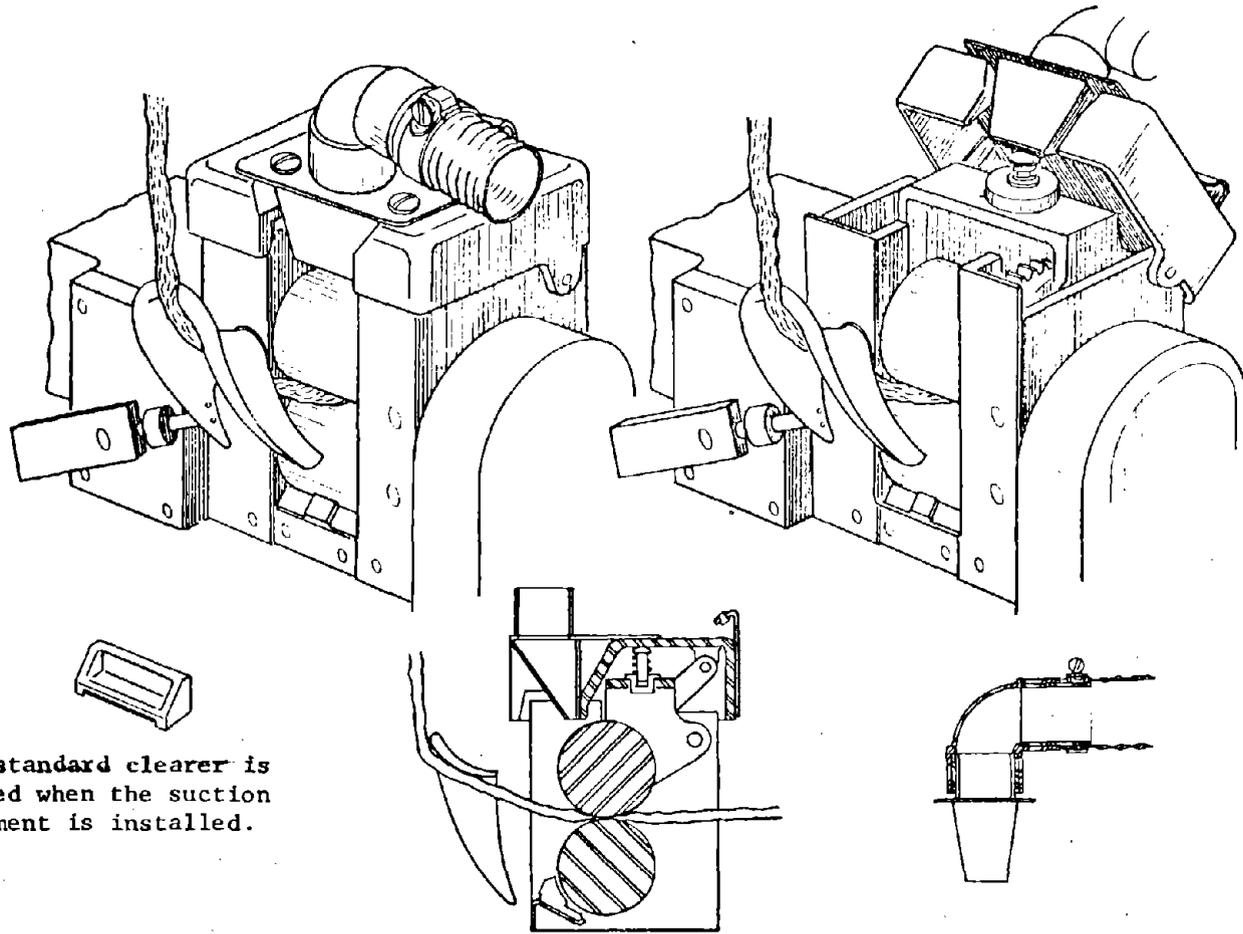
CARD ROOM
 CARDS = 800 CFM EA.
 CMC FANS = 800 " "
 TOTAL = 1600
 20 CARDS @ 1600 = 32,000
 2 FEED LINE FANS
 @ 1500 EA. = 3000
 TOTAL = 35,000

OPENING ROOM
 4 No. 11 CONDENSERS
 @ 3000 CFM EA. = 12,000
 10 HOPPER HOODS
 @ 600 CFM EA. 6000
 TOTAL = 18,000



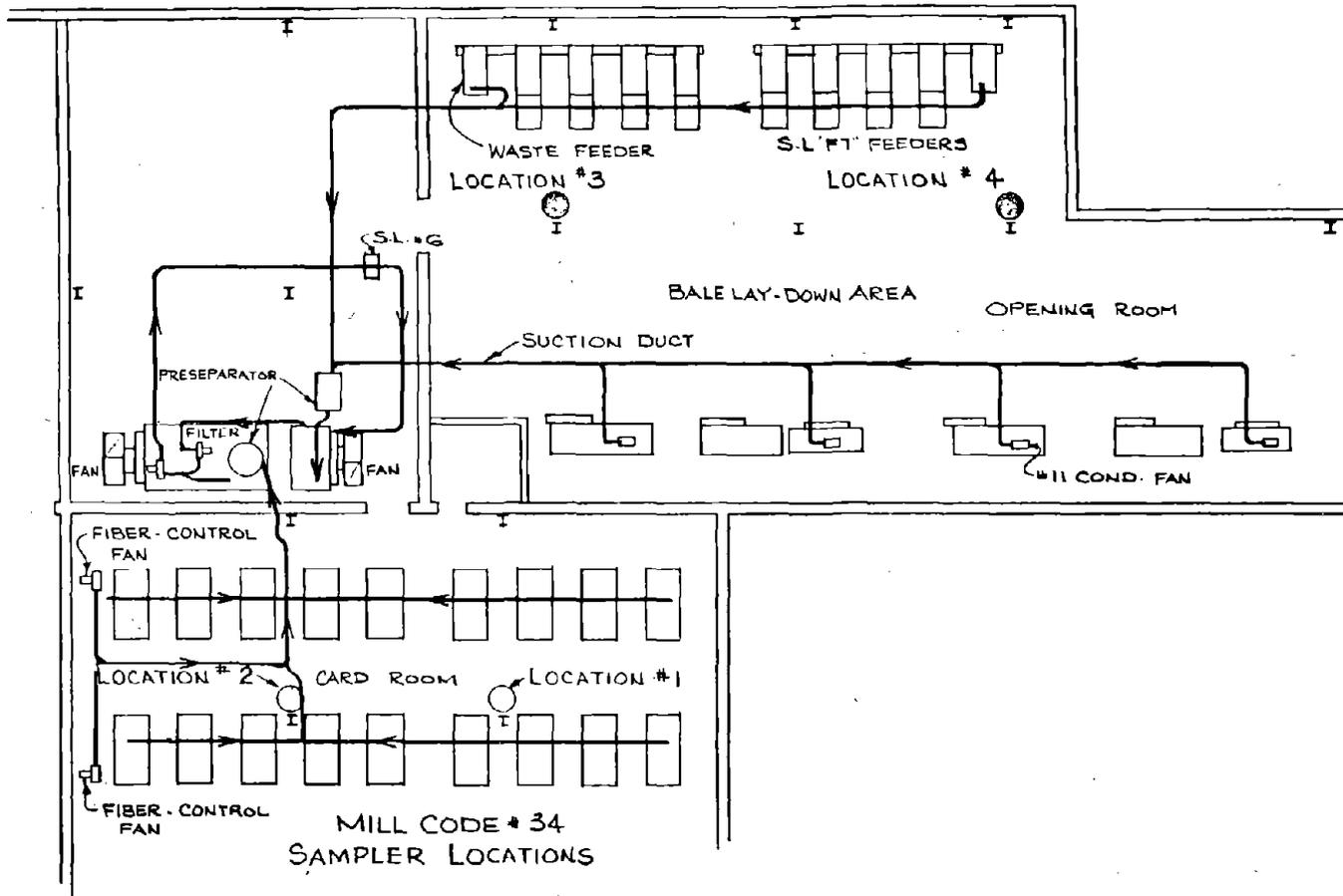
63

Filter System Schematic - Mill Code #34



This standard clearer is removed when the suction equipment is installed.

Suction Clearer for Crosrol Varga Top Calendar Roll



Dust Control System on Cards
at
Mill Code #36

Mill Code #36 manufactures denim. The "filling" section of the card room was equipped with a continuous automatic lint and dust control system. Twenty-three of the cards in this section were on 1" low middling cotton and 22 were on a 50-50 blend of cotton and polyester. The "warp" section was not equipped with a lint and dust control system and was processing 100% low middling cotton of 15/16" staple.

Production Machinery Specifications and Arrangement. Please see the "Sampler Locations" drawing which illustrates an unusual card room layout. The "filling" section of the card room shows two short lines of 6 cards each and one of 5 cards. The long line of 28 cards extended along the wall making a total of 45 cards in the "filling" section. Along the same wall were two rows of cards manufacturing sliver for warp yarns. In the "warp" section the line adjacent to the wall had 30 cards and the other contained 27 cards. This makes a total of 102 cards in this long card room, 45 of which were equipped with a lint and dust control system.

The cards in the "filling" end of the room were Saco-Lowell's, rebuilt for high-speed production and equipped with Crosrol Varga units. They were operating at a production rate of 44 lbs. per hour. Alongside the cards were drawing and roving frames. All of the machinery in the card room, drawing and roving areas was operating during dust sampling.

Lint and Dust Capture System. These cards were equipped with suction plenums as previously described in arrangement #A16M. Air quantities were as follows:

	<u>CFM</u>
Combination plenum, front of the card, with brush shield, 4½" OD suction tubing on the coiler side	372
Coiler trumpet cleaning, 1.9" OD suction tubing into 4½" elbow, coiler side	31
Lickerin plenum with back flats shield, 4½" OD suction tubing on coiler side	<u>397</u>
Total	800

The lint and dust control system was installed during the latter half of 1972 and was designed to control the lint and dust only. This was not an easy dust control job because of the high speed cards and the low grade stock.

Duct, Filter and Return Air System. The "Sampler Locations" drawing shows the arrangement of the suction duct system. This overhead duct system was handling a total of approximately 36,000 cfm. The lint and fly waste was separated at the preseparator and concentrated into 10% of the primary air quantity. This collected waste was received by a No. 6 condenser which was positioned between the rotary drum filter and the long line of 28 cards. The No. 6 condenser deposited the waste in the mill's regular waste handling containers and the air was recirculated to the rotary drum filter. The filter was 7 ft. in diameter and 7 ft. long and was operating at approximately 250 fpm face velocity.

Duct, Filter and Return Air System. (continued)

This mill was air conditioned for control of both humidity and temperature. There were no filters upstream of the washer in the air conditioning system at the "filling" end of the room. At the "warp" end, the air conditioning apparatus was protected by vee screens with nonwoven media. The air from the lint and dust control system was returned to the air conditioning system at the "filling" end of the room.

Summary of the Test Data.

Carding area ("filling" section) with lint and dust control system.

<u>Date</u>	<u>OSHA General-Area Sampler - mg/m³</u>		<u>Vertical Elutriator - mg/m³</u>	
	<u>Position #1</u>		<u>Position #2</u>	<u>Position #3</u>
6/6/73	0.92		--	--
6/7/73	--		0.38	0.35
6/19/73	0.76		0.37	0.33
6/20/73	--		0.28	0.29

Vertical elutriator samples at positions
2 and 3 combined:

n = 6	Minimum = 0.28
\bar{x} = 0.33	Median = 0.34
σ = 0.04	Maximum = 0.38

Carding area ("warp" section) without lint and dust control system.

<u>Date</u>	<u>OSHA General-Area Sampler - mg/m³</u>		<u>Vertical Elutriator - mg/m³</u>	
	<u>Position #5</u>		<u>Position #4</u>	<u>Position #6</u>
6/6/73	--		2.22	4.15
6/7/73	5.83		2.60	1.98
6/19/73	--		1.85	3.16
6/20/73	11.71		2.41	2.81

Vertical elutriator samples at positions
4 and 6 combined:

n = 8	Minimum = 1.85
\bar{x} = 2.65	Median = 2.51
σ = 0.74	Maximum = 4.15

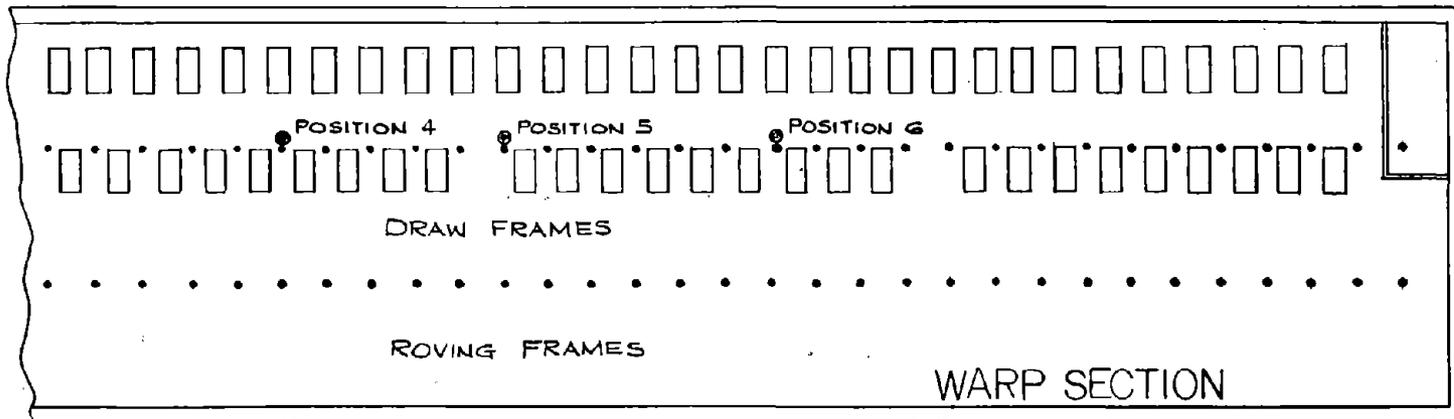
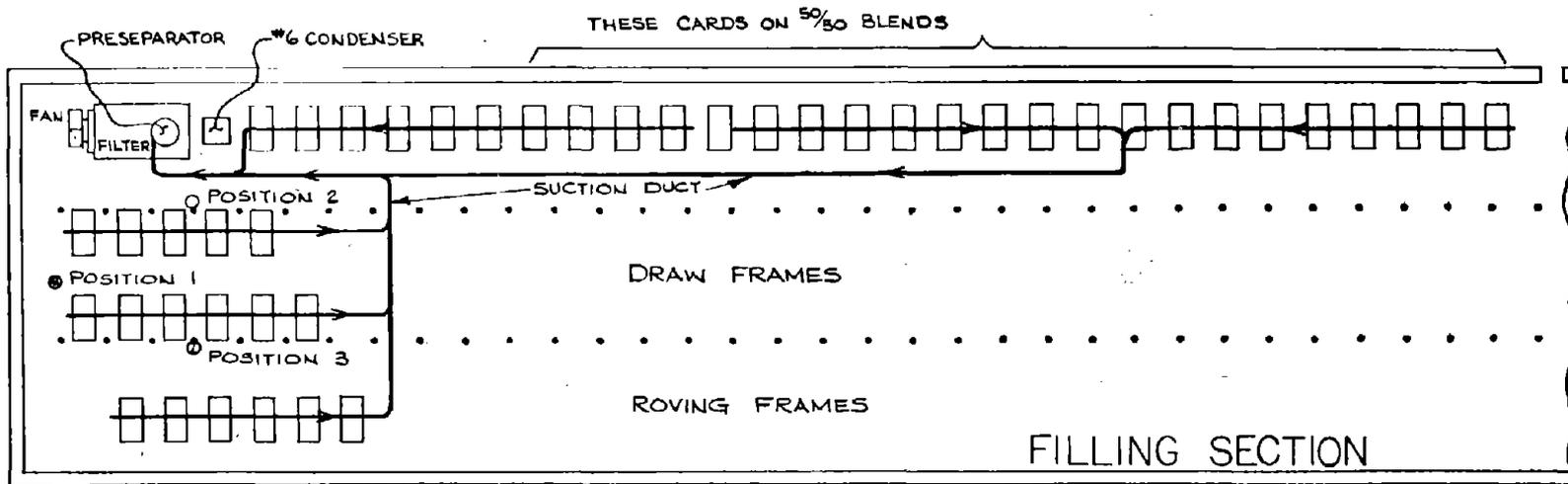
Comments and Conclusions. There was quite a visual contrast in the two sections of this room. This contrast was borne out by the OSHA General Area Samples which showed a 90.4% reduction in dust level at the end of the room which was equipped with the lint and dust control system. Also, based on the average figures, the invisible dust measured by the vertical elutriators showed a reduction of 87½%. Because of differences in the raw stock being processed and other factors, it must be recognized that the two ends of the room are not exactly comparable.

Comments and Conclusions. (continued)

The comparison between the OSHA general-area sampler measurements and the vertical elutriator will also be of some interest. Based on the average figures at the "clean" end of the room, the vertical elutriator measurements were 60.7% less than the OSHA general-area sampler. At the "dirty" end of the room, the vertical elutriator measurement was 69.7% less.

Positions 1, 2 and 3 were purposely based in the area where the cards are processing 100% cotton. This tends to make the opposite ends of the room more directly comparable (the cards in the "warp" section were on 100% cotton).

A lint and dust control system for the "warp" section of this card room has been ordered.



MILL CODE # 36 - CARD ROOM
SAMPLER LOCATIONS

Dust Control System on the Isolated Card
at
North Carolina Vocational Textile School

The North Carolina Vocational Textile School at Belmont, North Carolina, "manufactures" trained personnel for the textile industry in one of the most highly concentrated textile industrial areas in the nation. It has a well-equipped yarn manufacturing laboratory and was, therefore, an ideal place for probably the most comprehensive, individual study in this project. The program for this study was purposely set up as a severe dust control problem. Picker laps to process through the test card were secured from a textile plant which manufactures denim.

The laps were 38" wide weighing 16 ounces per yard for a total weight of approximately 51 lbs. (net). Specifications of the stock mix were as follows:

<u>Percentage</u>	<u>Class</u>	<u>Staple</u>	<u>Area Grown</u>
12.5	SLM	1-1/16"	East
37.5	LMT	1-1/16"	West
25.0	SLM	1-1/16"	West
12.5	LM	1-1/16"	West
12.5	Gran B	1-1/32"	West

Average Micronaire = 4.4

Shirley Analyzer data = 1.9% visible foreign matter, 0.3% invisible loss for total of 2.2%.

Card Specifications. The test card was a Whitin Model New "H" which was rebuilt for high speed production in 1968 by John D. Hollingsworth. It was a typical cotton card with revolving flats equipped with metallic clothing, a fiber retriever, Jenkins' screens, a doffer roll (instead of a doffer comb), and a Booth "sliver eye" knock-off mechanism. It was operated for the tests at a rate of 40 lbs. per hour making a 71 grain sliver. The lickerin was revolving at a rate of 775 rpm, the main cylinder at 310 rpm and the doffer at 25 rpm.

Lint and Dust Capture System. The only dust control equipment applied to this card for any of the tests were plenums as previously described for the front of the card and for the back of the card. The suction tubing arrangement was modified to achieve the full range of air quantities required. Specifications for the various tests were as follows:

<u>Arrangement A16M (Tubing) - (Air quantity varied by changing suction duct pressure)</u>	<u>Air Quantity - CFM</u>			
Combination plenum with flats brush shield, front of the card, 4½" OD suction tubing on the coiler side	372	465	558	651
Coiler trumpet suction nozzle, 1.9" OD suction tubing into 4½" OD elbow on coiler side	31	39	46	54
Lickerin plenum with back flats shield, 4½" OD suction tubing on the coiler side	<u>397</u>	<u>496</u>	<u>596</u>	<u>695</u>
Total	800	1000	1200	1400

<u>Arrangement A18M (Tubing)</u>	<u>Air Quantity - CFM</u>
Combination plenum with flats brush shield, front of the card, 4½" OD suction tubing on both sides	744
Coiler trumpet suction nozzle, 1.9" OD suction tubing into 4½" elbow on the coiler side	61
Lickerin plenum type B1 with back flats shield, 4½" OD suction tubing on both sides	<u>795</u>
Total	1600

Isolation Enclosure, Duct, Filter and Return Air System. Please refer to the "Test Facility - Isolated Card" drawing. It was necessary to enclose two cards to provide adequate working area around the test card. All operations for the study were performed only on the test card. The temporary enclosure was constructed of plywood and framing panels with sheets of polyethylene used for visibility and for piecing around ductwork, piping and other obstructions. There was no air pressure problem because the air supplied to the enclosure was matched to the air quantity exhausted. The doors shown on the enclosure drawing were kept closed during dust sampling except as required to operate the card and the samplers.

The suction plenums on the card were connected to a suction duct which extended across the room to a manually cleaned filter. This was a three cell vee-type unit covered with 1/2" nonwoven polyester media. It was equipped with an integral centrifugal fan and the air was discharged into the room from the top of the unit.

The supply-air unit consisted of primary vee-cell filters covered with two layers of nonwoven filter media, secondary high-efficiency pocket filters and a supply air fan.

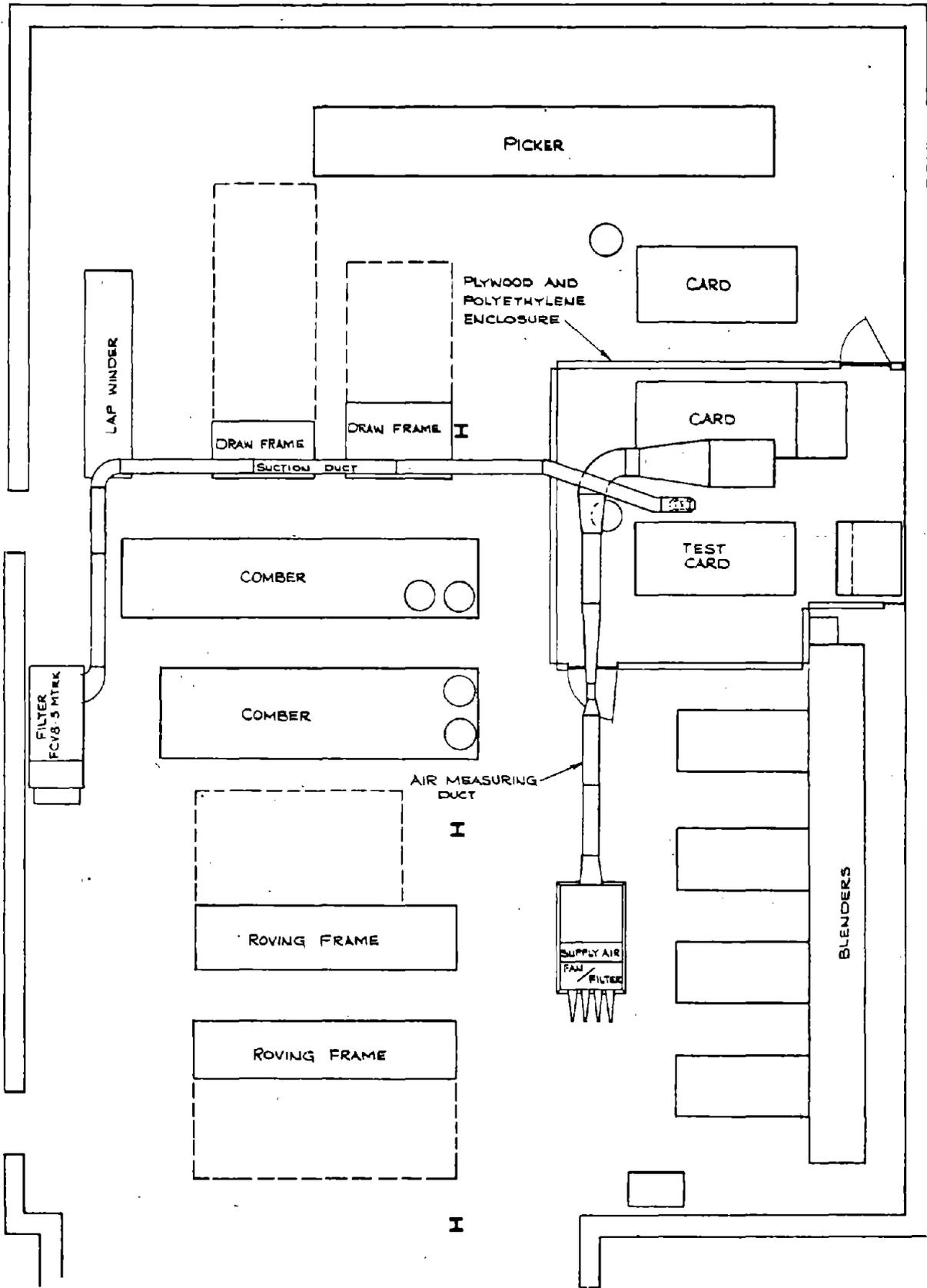
The supply-air filter consisted of a first stage vee-type unit with 4 vees 3 ft. high. These were covered with Chicopee "Viskon-Aire" two-ply media with tackifier nonwoven polyester. Maximum velocity through this first stage (at 1600 cfm) was 55 fpm.

The second stage consisted of pocket filters 2 ft. high x 3 ft. wide x 1 ft. deep. These were Chicopee "Viskon-Aire" Series 440 cartridge filters.

Efficiency ratings of each stage were as good or better than the following:

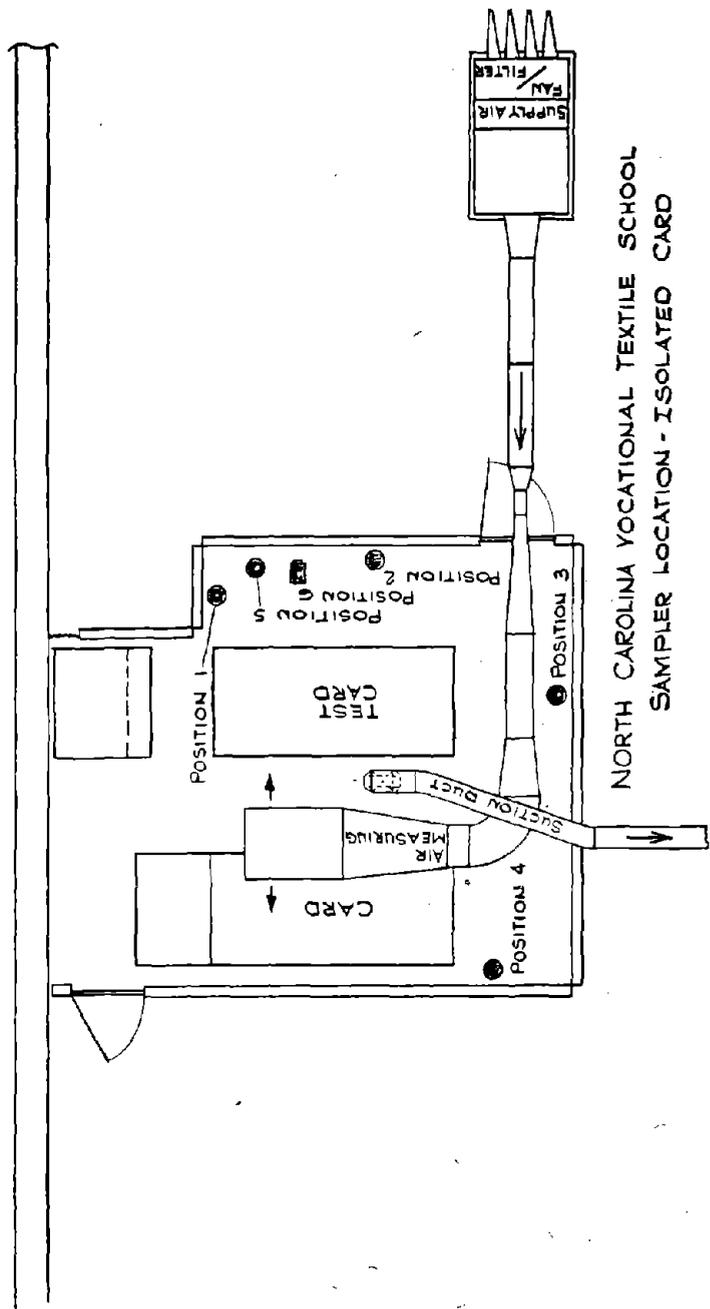
AFI Gravimetric	= 90%
NBS Atmospheric Dust	= 45%
NBS Dust Spot (Cottrell Dust)	= 97%
Royco - Particles larger than 8 microns	= 100%
- Particles larger than 2 microns	= 78%

The test card was the only production machinery in operation during the dust sampling experiments. This arrangement was designed for exclusive testing of the dust capture devices on the card.



NORTH CAROLINA VOCATIONAL TEXTILE SCHOOL

TEST FACILITY - ISOLATED CARD



NORTH CAROLINA VOCATIONAL TEXTILE SCHOOL
 SAMPLER LOCATION - ISOLATED CARD

Summary of the Test Data. Card operation without any dust control system applied. Both enclosure doors open, no exhaust or supply air fans running, suction plenums and all dust control equipment removed from the card and all card sealing modifications removed. This was the last of the dust sampling tests but is reported first to furnish a point of reference for the tests that followed.

Vertical Elutriator Samples (mg/m³) taken 7/12/73.

	<u>Position #1</u>	<u>Position #2</u>	<u>Position #3</u>	<u>Position #4</u>
	4.77	7.67	5.76	4.62
	6.10	7.31	5.94	5.88
	4.45	6.23	5.74	6.52
	<u>5.80</u>	<u>5.61</u>	<u>4.93</u>	<u>6.76</u>
n =	4	4	4	4
\bar{x} =	5.28	6.71	5.59	5.95
σ =	0.79	0.95	0.45	0.96

Positions #1, 2, 3 and 4 above combined.

n =	16	Minimum =	4.45
\bar{x} =	5.88	Median =	5.84
σ =	0.91	Maximum =	7.67

OSHA General Area Samples (mg/m³) taken 7/12/73

High Volume Samples (mg/m³) taken 7/12/73

	<u>Position #5</u>	<u>Position #6</u>
	10.99	10.54
	12.67	11.22
	8.49	9.47
	9.42	11.82
	-	<u>11.13</u>
n =	4	5
\bar{x} =	10.39	10.84
σ =	1.84	0.89

All dust sampling data that follows was taken with the dust control system in operation.

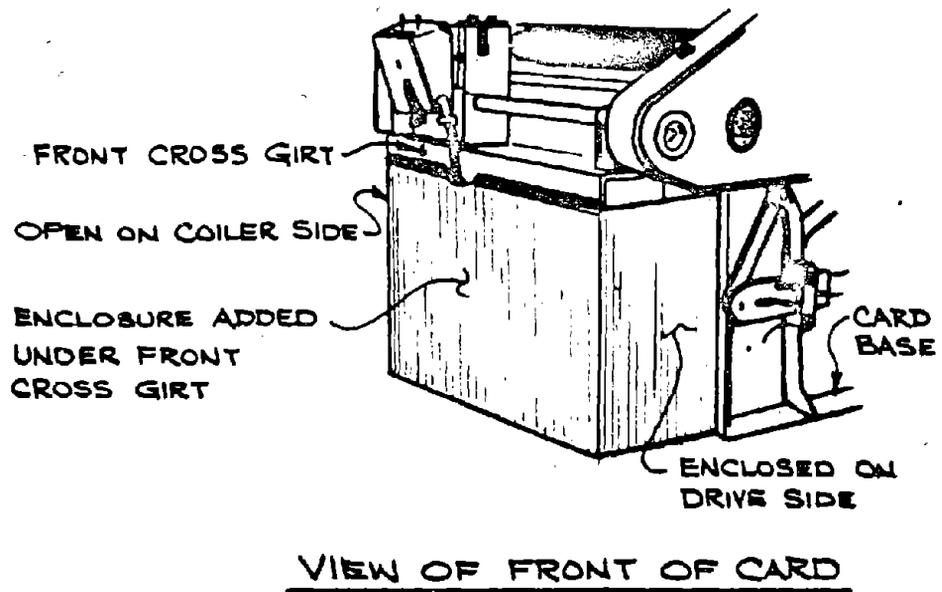
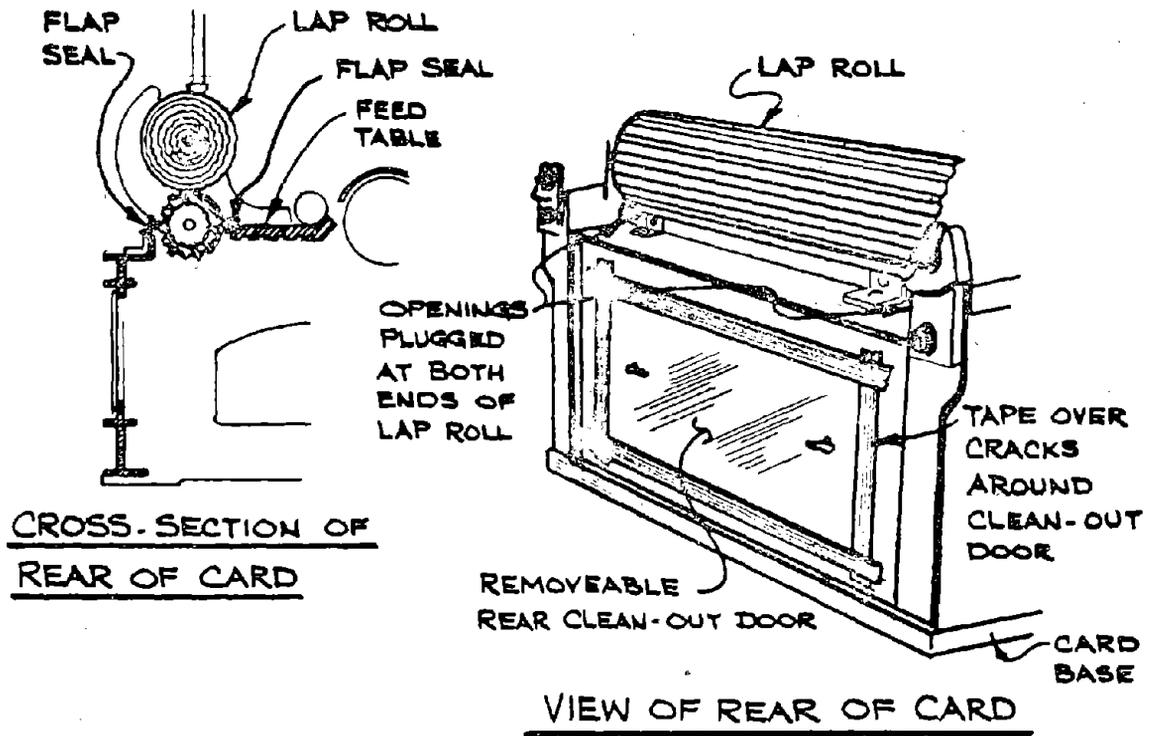
Start-up Tests:

Card running and 800 cfm on dust control system.

Vertical Elutriator Samples (mg/m³)

<u>Date</u>	<u>Position #1</u>	<u>Position #2</u>	<u>Position #3</u>	<u>Position #4</u>
4/10/73	0.67	0.63	0.71	0.64
4/11/73	0.67	0.78	0.76	0.75
4/12/73	0.57	0.66	0.76	0.63

As the above tests proceeded to indicate unsatisfactory performance, observations were made to determine causes. Changes were made in various things to improve dust control without increase in air quantity or modifications of the basic dust control application. Excessive dust was observed to be escaping around a poorly fitted clean-out door in the base at the back of the card. This leak was sealed with tape. Excessive dust was also being blown out of the unusually large gap between the lap roll and the card base. A partial cover was added to reduce this leakage and the following sample taken:



Vertical Elutriator Samples (mg/m ³)				
<u>Date</u>	<u>Position #1</u>	<u>Position #2</u>	<u>Position #3</u>	<u>Position #4</u>
4/13/73	0.55	0.63	0.68	0.65

A check was next made to determine whether some outside influence was affecting the measurements. This was accomplished by stopping the card operation but continuing the operation of the dust control system with the following results:

Vertical Elutriator Samples (mg/m ³)				
<u>Date</u>	<u>Position #1</u>	<u>Position #2</u>	<u>Position #3</u>	<u>Position #4</u>
4/16/73	0.11	0.14	0.11	0.11

The 4/16/73 data indicated that considerable lint and dust that had settled in and on ducts, on the walls and on the equipment inside the enclosure was being disturbed and kept in suspension by excessive turbulence. This was caused by high velocity and arrangement of the exhaust from the supply air duct system. Plans were made to modify the diffuser and arrangement.

While this modification was in preparation, an enclosure from floor to front top cross girt was fitted at the front of the card. It had been observed during preceding tests that an unusual amount of dust was being generated under the doffer roll. This was reasoned to be natural because this particular device was usually applied on cards operating at speeds of not more than 20 to 25 pounds per hour and present operation was almost twice as fast. The enclosure was expected to confine the blowing out of this dust. This arrangement was then tested.

Vertical Elutriator Samples (mg/m ³)				
<u>Date</u>	<u>Position #1</u>	<u>Position #2</u>	<u>Position #3</u>	<u>Position #4</u>
4/18/73	0.42	0.40	0.47	0.41

That improvement was followed by modification of the supply-air diffuser for the following test:

Vertical Elutriator Samples (mg/m ³)				
<u>Date</u>	<u>Position #1</u>	<u>Position #2</u>	<u>Position #3</u>	<u>Position #4</u>
4/30/73	0.31	0.35	0.30	0.26

The 4/30/73 data was considered satisfactory and the condition, adjustments and arrangements of the card and the test setup remained unchanged for the remainder of the program. The 4/18/73 and 4/30/73 data is included in the following reports on dust samples taken for checking performance at 800 cfm.

Increasing the air quantity was achieved by increasing the duct pressure through 1400 cfm. For 1600 cfm, it was necessary to apply suction tubing to both ends of the plenums. Change in air handling factors was as follows:

	Air Quantity CFM				
	<u>Suction Tubing - Single Connected</u>				<u>Double</u>
	<u>800</u>	<u>1000</u>	<u>1200</u>	<u>1400</u>	<u>1600</u>
Duct Pressure (inches wg)	2.10	3.28	4.73	6.43	4.0
Air HP	0.264	0.516	0.893	1.416	1.007
Ratio of Air and HP required	1.00	1.95	3.38	5.36	3.81

Dust Levels @ 800 cfm

Vertical Elutriator Samples (mg/m³)

<u>Date</u>	<u>Position #1</u>	<u>Position #2</u>	<u>Position #3</u>	<u>Position #4</u>
4/18/73	0.42	0.40	0.47	0.41
4/30/73	0.31	0.35	0.30	0.27
5/16/73	0.33	0.37	0.33	0.26
5/17/73	0.37	0.48	0.50	0.30
5/21/73	0.34	0.37	0.35	0.20
5/22/73	0.34	0.37	0.32	0.27

n = 24
 \bar{x} = 0.35
 σ = 0.07

Minimum = 0.20
 Median = 0.35
 Maximum = 0.50

OSHA General Area Samples (mg/m³)

<u>Date</u>	<u>Position #5</u>
4/18/73	0.45
4/30/73	0.37
5/16/73	0.36
5/17/73	0.43
5/21/73	0.27
5/22/73	0.33

n = 6
 \bar{x} = 0.37
 σ = 0.07

Min. = 0.27
 Med. = 0.37
 Max. = 0.47

High Volume Samples (mg/m³)

<u>Position #6</u>	<u>4/18/73</u>	<u>4/30/73</u>
	0.75	0.75
	0.59	0.62
	0.51	0.55
	0.58	0.68
	0.50	0.58

n = 10
 \bar{x} = 0.61
 σ = 0.09

Min. = 0.50
 Med. = 0.59
 Max. = 0.75

Dust Levels @ 1000 cfm

Vertical Elutriator Samples (mg/m³)

<u>Date</u>	<u>Position #1</u>	<u>Position #2</u>	<u>Position #3</u>	<u>Position #4</u>	<u>Average</u>
5/23/73	0.28	0.29	0.22	0.23	0.26

OSHA General Area Sample (mg/m³)

Taken 5/23/73 @ position #5 = 0.30

Dust Levels @ 1200 cfm

Vertical Elutriator Samples (mg/m³)

<u>Date</u>	<u>Position #1</u>	<u>Position #2</u>	<u>Position #3</u>	<u>Position #4</u>	<u>Average</u>
5/24/73	0.24	0.25	0.23	0.20	0.23

OSHA General Area Sample (mg/m³)

Taken 5/24/73 @ position #5 = 0.28

Dust Levels @ 1400 cfm

Vertical Elutriator Samples (mg/m³)

<u>Date</u>	<u>Position #1</u>	<u>Position #2</u>	<u>Position #3</u>	<u>Position #4</u>	<u>Average</u>
5/25/73	0.21	0.21	0.21	0.20	0.21

OSHA General Area Sample (mg/m³)

Taken 5/25/73 @ position #5 = 0.24

Dust Levels @ 1600 cfm

Vertical Elutriator Samples (mg/m³)

<u>Date</u>	<u>Position #1</u>	<u>Position #2</u>	<u>Position #3</u>	<u>Position #4</u>
5/30/73	0.19	0.25	0.22	0.23
5/31/73	0.22	0.19	0.18	0.18
6/1/73	0.15	0.15	0.14	0.14
6/14/73	0.10	0.12	0.11	0.08

n = 16
 \bar{x} = 0.17
 σ = 0.05
Minimum = 0.08
Median = 0.17
Maximum = 0.25

OSHA General Area Samples (mg/m³)

<u>Date</u>	<u>Position #5</u>		
5/30/73	0.23	n = 4	Minimum = 0.12
5/31/73	0.22	\bar{x} = 0.17	Median = 0.17
6/1/73	0.12	σ = 0.06	Maximum = 0.23
6/14/73	0.12		

Fibrograph Analysis

These are averages of the Fibrograph analysis of the collected waste on each test run. The collected waste consisted of flats strips, lint, fly and dust collected by the dust control system filter. It did not include ends-down and other waste at the card.

<u>Percent of Fibers</u>	<u>Minimum Fiber Length (inches)</u>				
	<u>800 cfm</u>	<u>1000 cfm</u>	<u>1200 cfm</u>	<u>1400 cfm</u>	<u>1600 cfm</u>
100	.15	.15	.15	.15	.15
66.7	.264	.240	.272	.269	.274
50	.337	.305	.346	.332	.350
2.5	1.032	.977	.977	.91	.969

Weight of Waste Collected

All waste collected during each test run by the dust control system filter was weighed and running time of test was recorded. Did not include ends-down, under-card or other waste occurring at the card which was (intentionally) not controlled by the suction section.

<u>Average Weight of Collected Waste (ounces/hour)</u>				
<u>800 cfm</u>	<u>1000 cfm</u>	<u>1200 cfm</u>	<u>1400 cfm</u>	<u>1600 cfm</u>
15.69	16.95	17.34	16.55	18.63

Averages of All Tests

<u>Air Quantity (cfm)</u>	<u>Dust Level (mg/m³)</u>		<u>Weight of Waste (oz./hr.)</u>
	<u>Vertical Elutriator</u>	<u>OSHA Area</u>	
800	0.35	0.37	15.69
1000	0.26	0.30	16.95
1200	0.23	0.28	17.34
1400	0.21	0.24	16.55
1600	0.17	0.17	18.63
-0-	5.88	10.39	--

Hot-Wire Anemometer Readings

This study was not intended to be a comprehensive analysis of velocities imposed around the card by the dust capture plenums. It was not a part of the original assignment but, rather, an afterthought. It is reported here only to furnish some "ballpark" figures on the order of magnitude of velocities around the card necessary to capture the airborne dust and fly.

Lickerin Area - Velocity (fpm) - Position #8

<u>cfm</u>	<u>Left Side</u>	<u>Right Side</u>
800	190	190
1000	220	200
1200	150	130
1400	160	150
1600	170	170

Doffer Area - Velocity (fpm)

<u>cfm</u>	<u>Position #1</u>		<u>Position #2</u>		<u>Position #3</u>	
	<u>Left Side</u>	<u>Right Side</u>	<u>Left Side</u>	<u>Right Side</u>	<u>Left Side</u>	<u>Right Side</u>
800	70	65	75	70	80	70
1000	75	60	85	70	110	80
1200	70	70	95	75	100	80
1400	75	60	85	80	95	90
1600	80	80	100	90	120	100

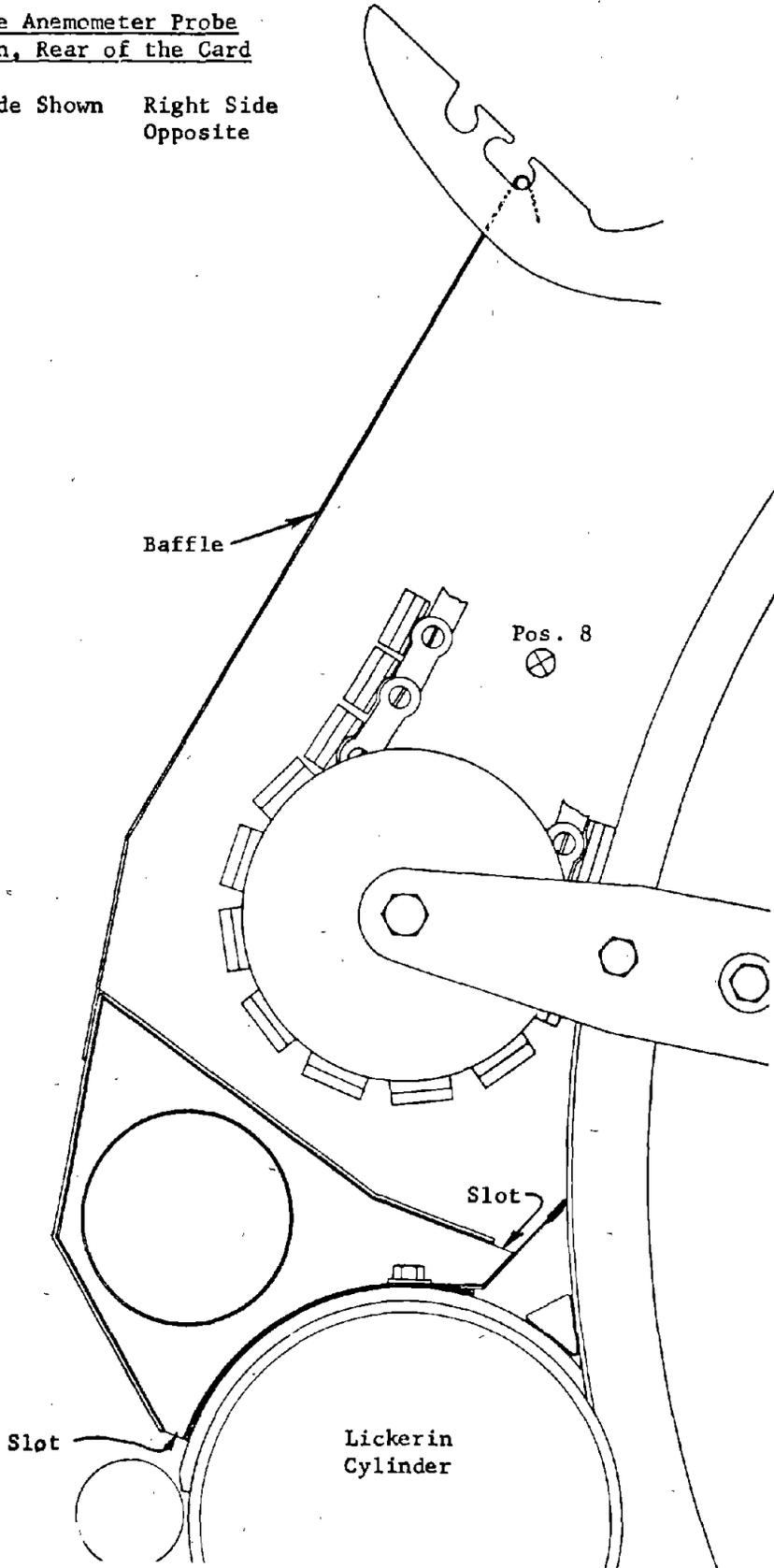
<u>cfm</u>	<u>Position #4</u>		<u>Position #5</u>		<u>Position #6</u>	
	<u>Left Side</u>	<u>Right Side</u>	<u>Left Side</u>	<u>Right Side</u>	<u>Left Side</u>	<u>Right Side</u>
800	90	90	80	65	90	40
1000	100	120	90	110	100	40
1200	120	120	100	100	95	40
1400	130	90	110	100	80	40
1600	160	160	120	170	140	60

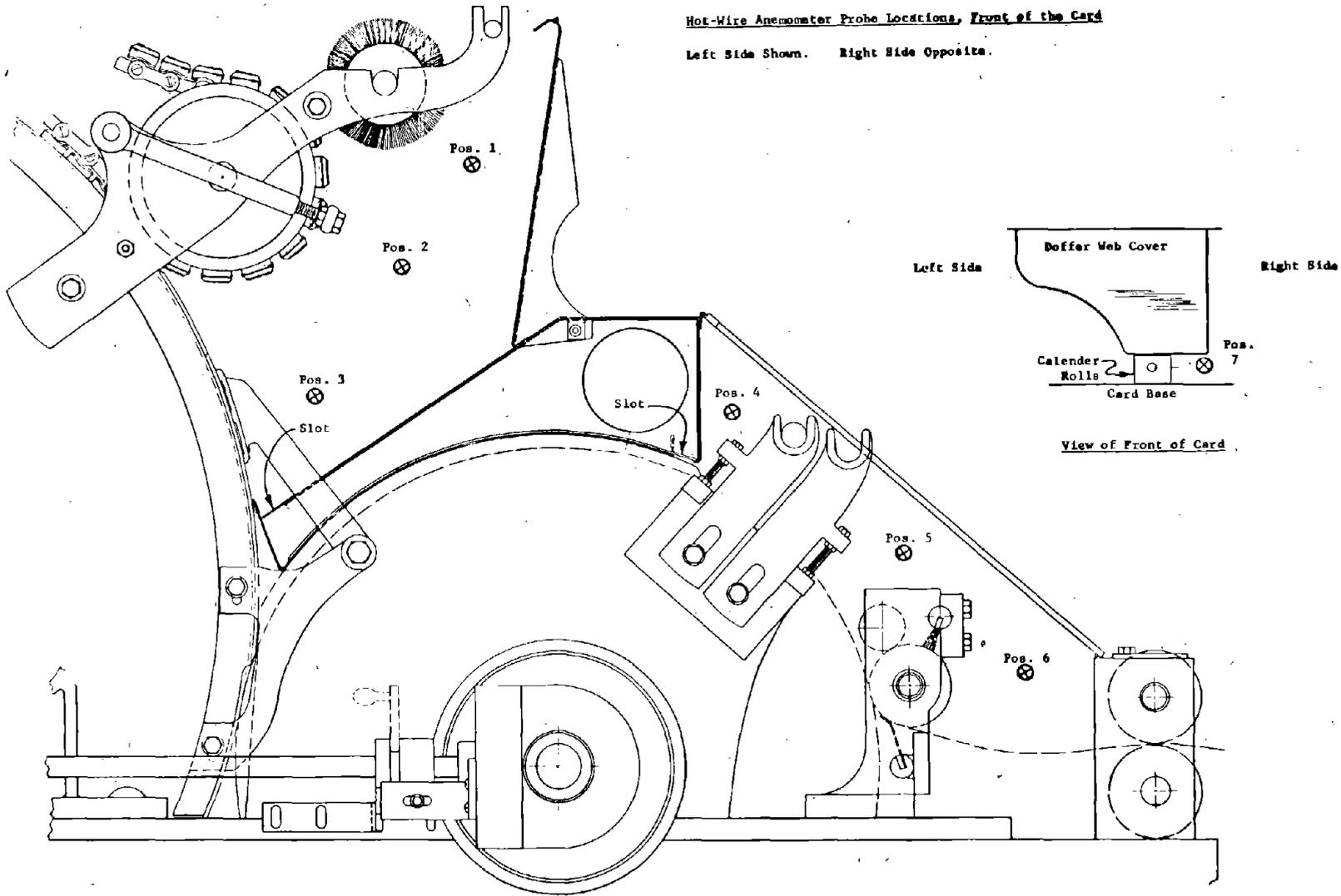
Front of Web Cover - Position #7

<u>cfm</u>	<u>fpm</u>
800	40
1000	45
1200	50
1400	50
1600	60

Hot-Wire Anemometer Probe
Location, Rear of the Card

Left Side Shown Right Side
Opposite





Hot-Wire Anemometer Probe Locations, Front of the Card

Left Side Shown. Right Side Opposite.

Doffer Web Cover

Left Side

Right Side

Calender
Rolls

Card Base

Pos.
7

View of Front of Card

Comments and Conclusions.

The data indicates that control of the dust level in the area around this card to a level not exceeding 0.5 mg/m³ can be obtained with minimum equipment (a suction plenum at the doffer end and another at the lickerin end of the card) and at minimum air quantity (800 cfm).

The dust level around this card can be controlled to a level not exceeding 0.2 mg/m³ at 1600 cfm with minimum equipment.

The minimum practical air quantity to achieve a dust level not exceeding 0.5 mg/m³ is 800 cfm.

Modifications in the dust control system are necessary above 1200 cfm to prevent decreased production efficiency of the card. This is explained in some detail in the comments that follow.

Note: Dust levels quoted above are measured by the vertical elutriator.

The curves that follow are a plot of the isolated card test results. The lower curve shows the mean dust concentration (as measured by the 4 vertical elutriators) variation as a function of air quantity. The upper curve shows the quantity of waste collected in the filter at the same air quantities. The curve drawn for the waste collected disregards the data point for 1400 cfm.

A least-squares curve fit of the dust concentration data (including the data for zero air quantity, i.e., with no suction cleaning) yielded a best fit equation in the form:

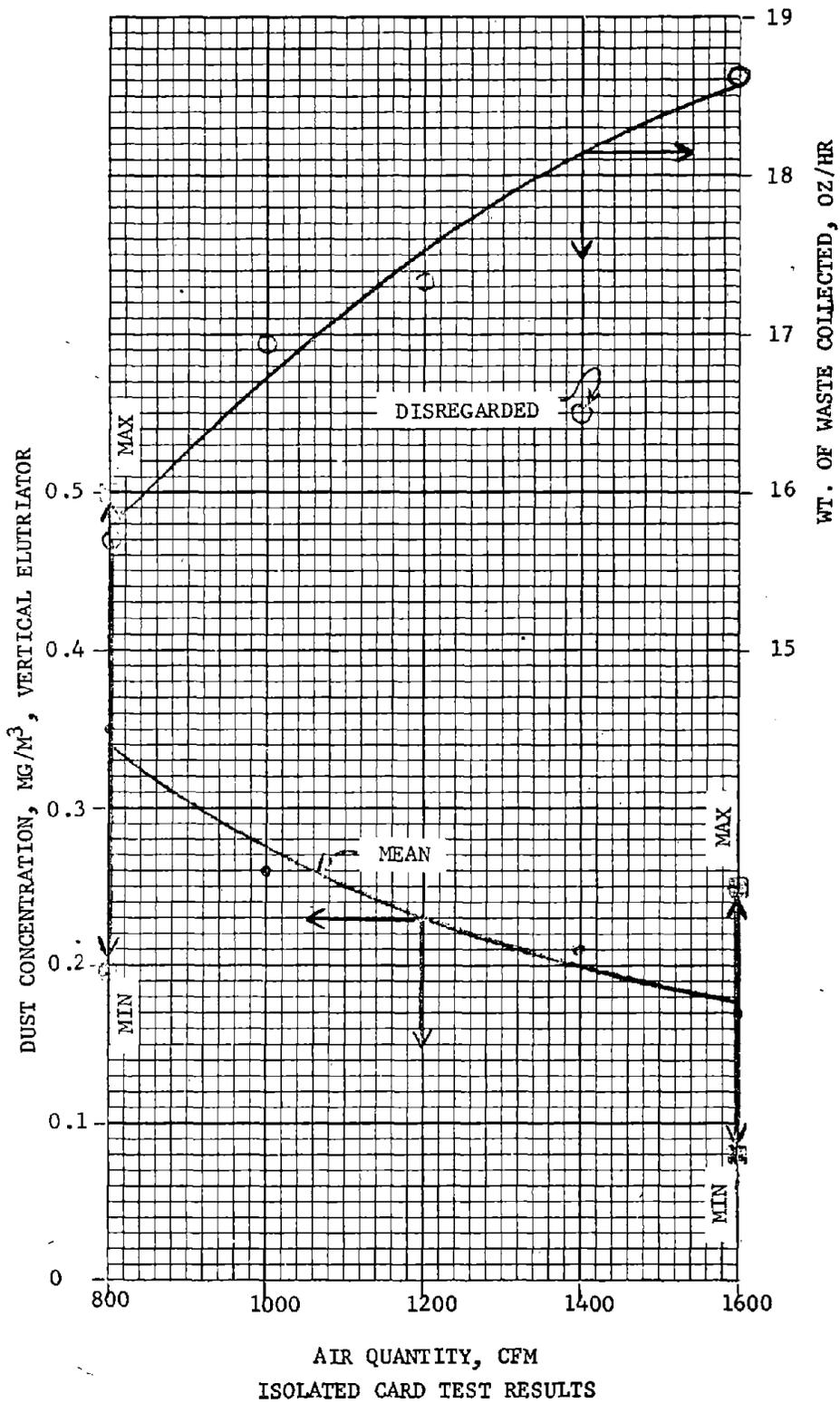
$$\text{Dust Concentration, mg/m}^3 = \frac{1}{A + B \cdot Q, \text{ CFM}}$$

and the coefficients were as follows:

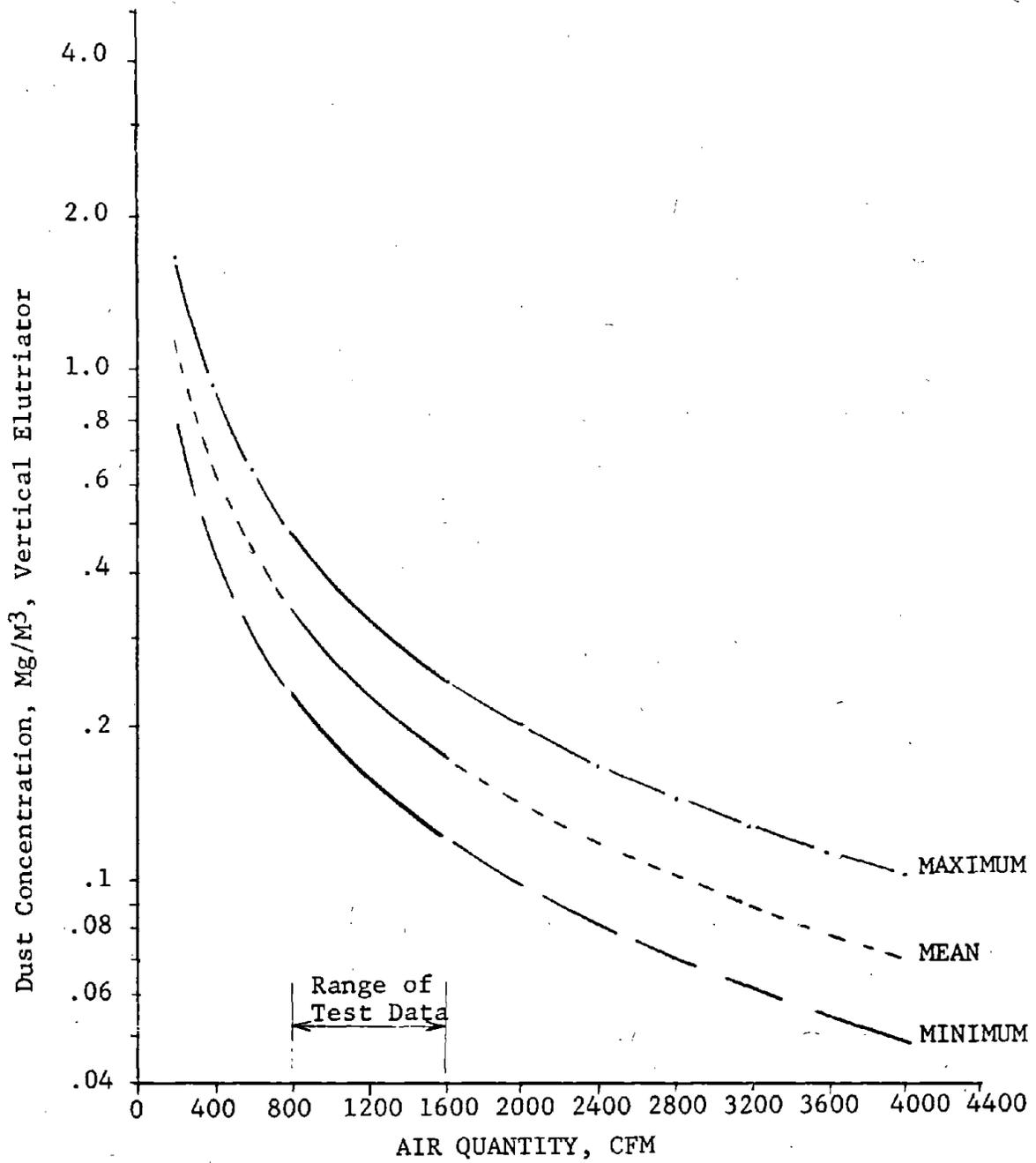
<u>Dust Concentration</u>	<u>Coefficients</u>	
	<u>A</u>	<u>B</u>
Maximum	0.1086	0.002419
Mean	0.1678	0.003476
Minimum	0.2593	0.004994

Plotting these equations for higher air quantities, as shown on the next curve, it is found that air quantities required for 0.2 and 0.1 mg/m³ maximum dust levels would be approximately 2000 cfm and 4100 cfm respectively, for the design of suction attachments which were tested. For mean dust levels of 0.2 and 0.1 mg/m³, the air quantities required are approximately 1400 and 2800 cfm respectively.

This test was purposely set up to establish a severe dust control problem. The picker laps fitted this plan well and no refinement of the card component settings was made to reduce lint generation. Also, the doffer roll mechanism on the card was operating at excessive speed of 40 lbs. per hour. The high vertical elutriator readings taken without the dust control system in operation confirms the severity of the test. The fact that the dust level objective was not obtained without stopping some of the blowout around the base of the card is further indication of the severity of the dust control problem.



AIR QUANTITY, CFM
ISOLATED CARD TEST RESULTS



Extrapolation of Dust Concentration Data on Isolated Card

Comments and Conclusions. (continued)

The data on the horsepower required for increased air quantity was included in this report for the benefit of those not familiar with the characteristics of air handling systems. It is obvious from these figures that it can be expensive to increase air quantity on a given system without modification of the system to match the new requirements.

The average vertical elutriator figures show that the dust level around the card was decreased by 94.0% when the dust control system was operating at 800 cfm. At 1600 cfm, the dust level was reduced 97.1%.

There were no additional problems with the web, piecing-up or laying up the lap when the air quantity was increased up to 1200 cfm. However, at 1400 cfm there was moderate lifting and waving of the web which did not result in actual lap-ups around the doffer. There was also some difficulty in inserting the sliver into the coiler trumpet. The loss in production efficiency which would result from such difficulties might make operation at 1400 cfm impractical. At 1600 cfm there was considerable lifting and waving of the web with occasional laps around the doffer roll and its clearer. Ends-down at the calender rolls due to tearing and waving of the web required constant attention of the operator. The excessive velocity of the air moving around the web also increased difficulties of piecing-up which resulted in large increases of piecing-up waste. Also, when piecing up a new lap at the back of the card, there was some difficulty in preventing the lap from being sucked into the back orifice of the lickering plenum. These operating difficulties were sufficient to make 1600 cfm impractical with only these two plenums.

Description
Lint and Dust Capture Devices for Drawing Frames

All modern high-speed drawing frames have a built-in lint and dust capture system combined with a pneumatic/mechanical drafting roll clearer system. These integral machine systems are complete with a waste separator/collector and fan unit. The lint-waste is retained in the collector unit but most of the dust goes through the screen and is blown back into the room. This dust can be controlled by capturing it in the air exhausted by the collector unit and cleaning it in central automatic filters. A positive connection is not made because the draw frame must be started without suction around the drafting rolls.

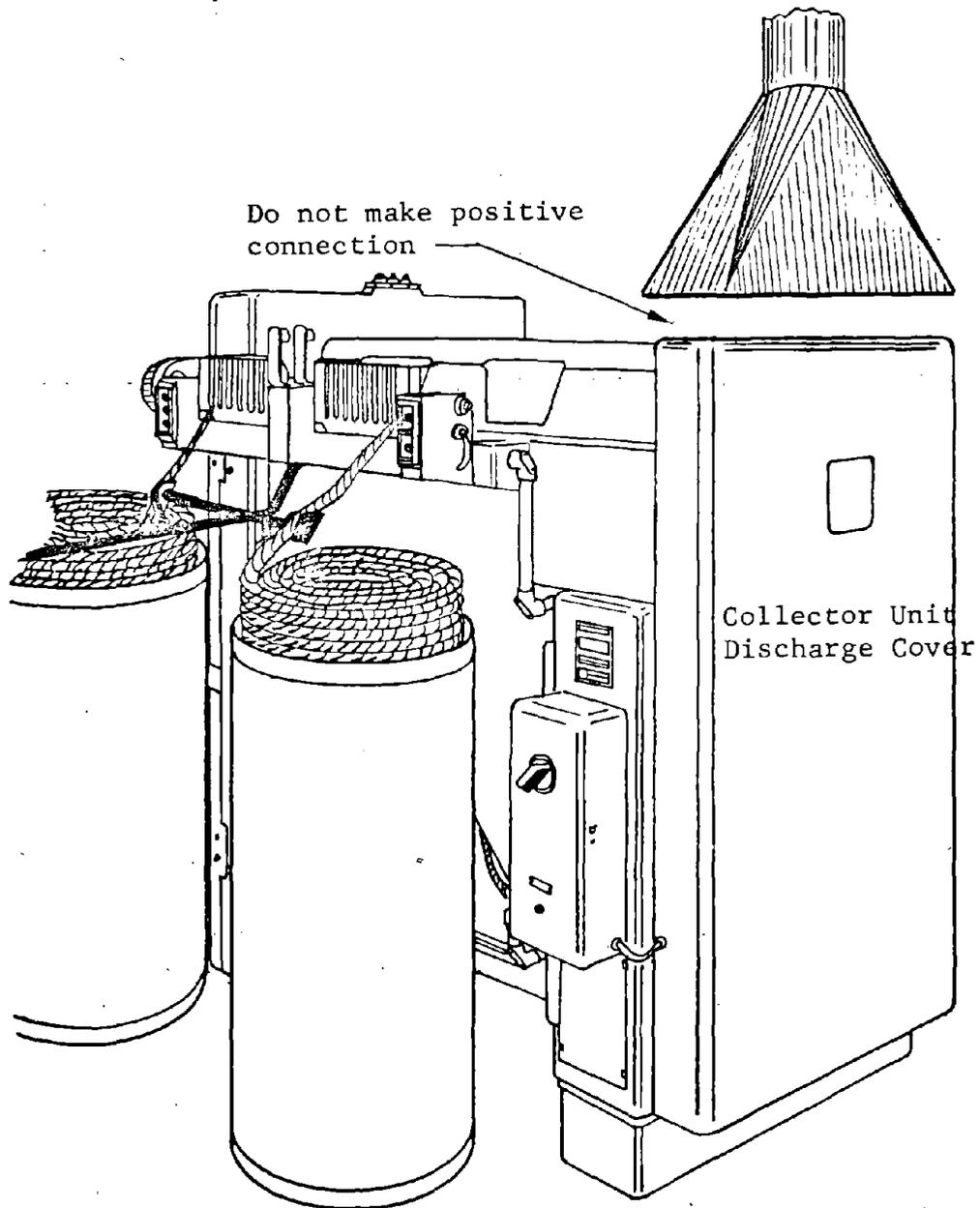
High speed drawing after combing often requires a power creel which creates additional fly and dust. Some applications may require a suction hood to control the dust. Air quantity for drawing frames are as follows:

Air Quantities for Drawing Frames

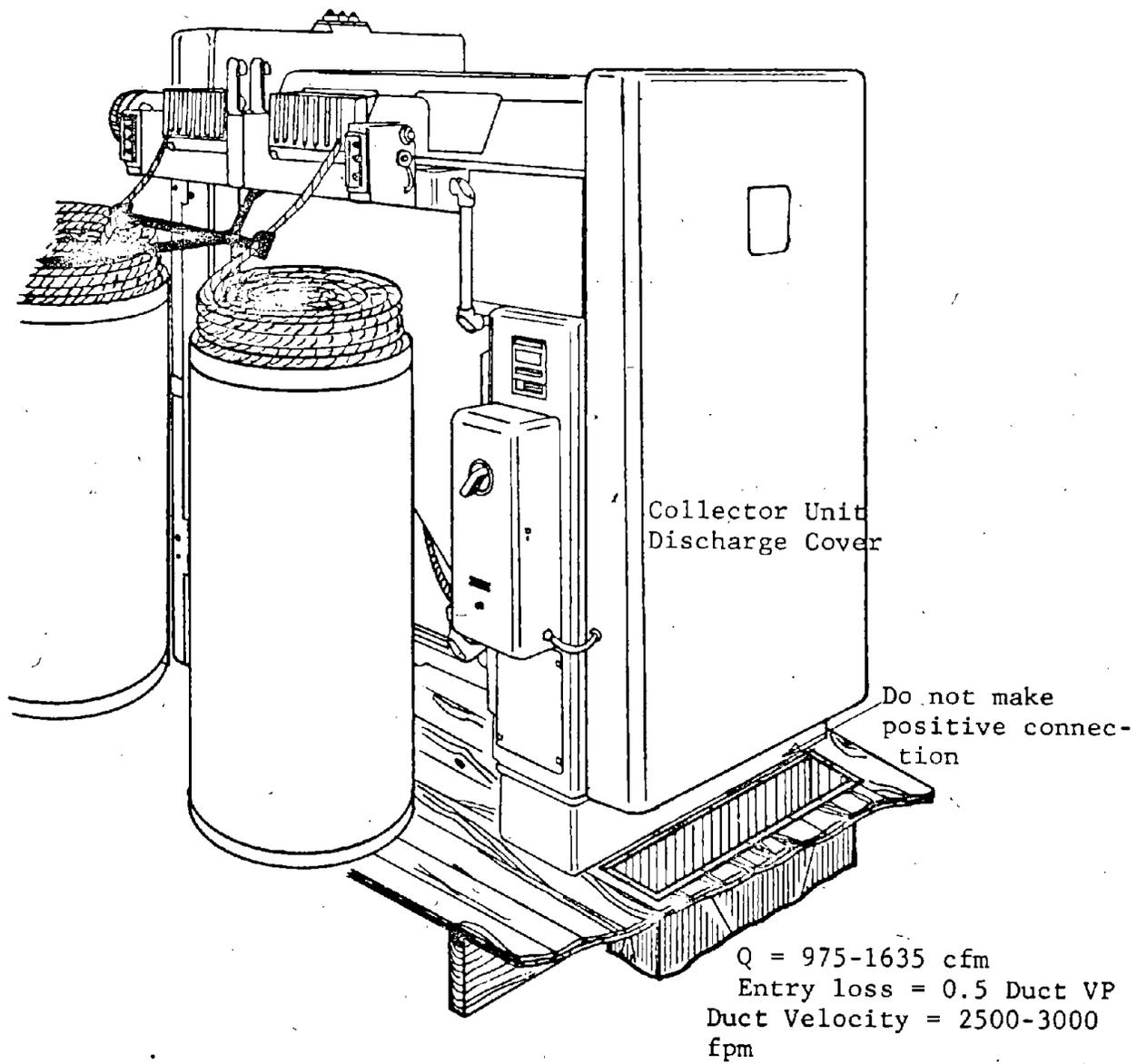
	<u>Cfm per Frame</u>
Saco-Lowell	
Versamatic, 2 deliveries-----	900 Max.*
Whitin	
Evendraft, 2 deliveries	
Prior to 1965-----	975/1230*
After 1965	
Without lifter-roll cleaning-----	1230/1560*
With single-orifice lifter-roll cleaning----	1305/1615*
With double-orifice lifter-roll cleaning----	1335/1635*
Dust Control Hoods Over Power Creels	
Saco-Lowell and Whitin-----	75-150 cfm/ft ² of open area (Recommended)

*The pneumatic/mechanical roll clearer system on drawing frames is sensitive to the air quantity in relation to the materials being processed. The air quantity may be adjusted by fan size selection and by damper control. Air quantities shown are for clean collector unit screens. As waste accumulates in collector unit the air quantity is reduced.

Q = 975-1635 cfm
Entry Loss = 0.25 Duct VP
Duct Velocity = 2500-3000 fpm



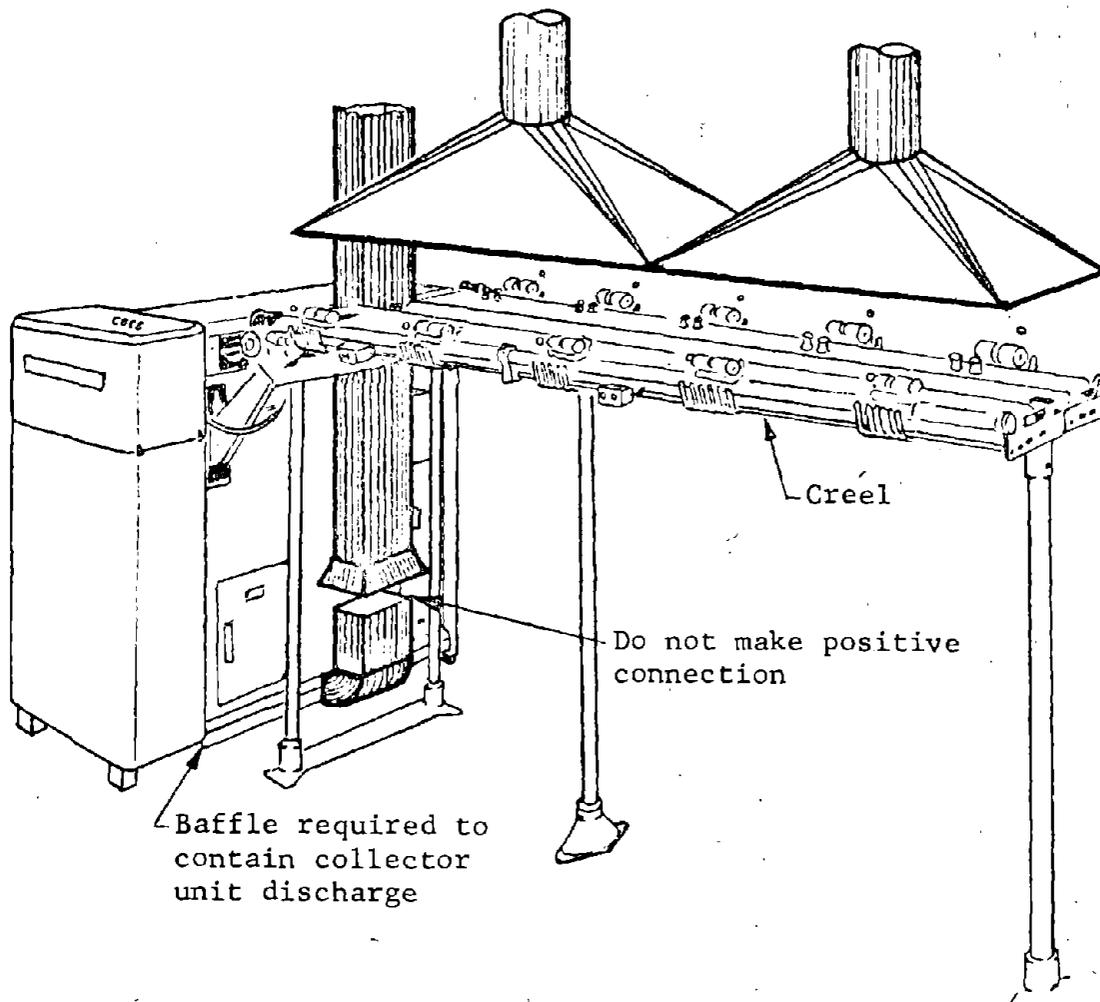
Whitin M7 2 Delivery Draw Frame with Top Discharge



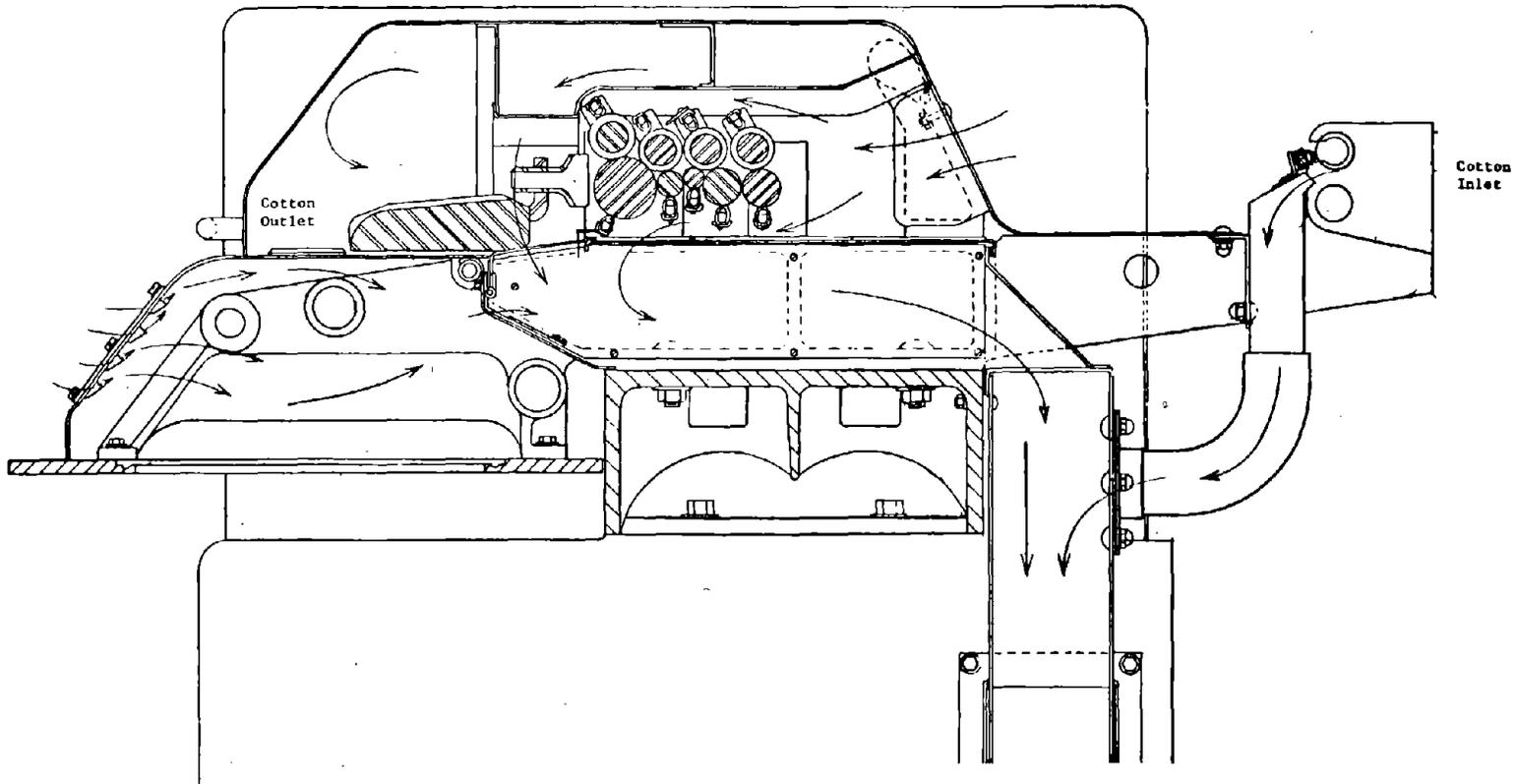
Whitin M7 2 Delivery Draw Frame with Bottom Discharge

Collector Unit Discharge
Q = 900 cfm (Typical)
Entry Loss = 0.25 Duct VP
Duct Velocity = 2500-3000 fpm

Creel Hood
Q = 75-150 cfm/ft² of open area
Entry Loss = 0.25 Duct VP
Duct Velocity = 2500-3000 fpm



Saco Lowell Versamatic 2 Delivery Draw Frame



SCHMATIC OF AIR FLOW THROUGH WHITIN
MODEL M7 DRAW FRAME STANDARD BUILT-IN VACUUM CLEANING SYSTEM

Dust Control System on the Isolated Draw Frame
at
Mill Code 38

Mill Code 38 manufactures cotton, synthetic, and blended yarns, cordage and twines. A high speed draw frame processing low grade stock (end product sales yarn for chenille) was selected for study.

Specifications of the stock mix were as follows:

<u>Percentage</u>	<u>Description</u>
50	Comber Noils
30	Flats Strips
20	15/16" Staple Low Middling Cotton

Shirley Analyzer data = 1.0% visible foreign matter, 1.1% invisible loss for total of 2.1%.

Draw Frame Specifications. The test draw frame was a Whitin Model M7B two delivery frame producing 800 fpm/delivery of 62 grain/yd breaker drawing sliver. The sliver cans were 20" diameter and 42" high. The creel was set up for a "nested" can arrangement with 8 doublings per delivery.

Lint and Dust Capture System. The dust control equipment applied to the draw frame consisted of a suction hood over the discharge of the collector unit. See the following drawing for arrangement. The air quantity discharged by this unit was 1600 cfm when the collector unit screen was clean.

Isolation Enclosure, Duct, Filter and Return Air System. Refer to the "Test Facility - Isolated Draw Frame" drawing. The temporary enclosure was constructed of plywood and framing panels with sheets of polyethylene used for visibility and for piecing around ductwork, piping and other obstructions. The air quantity supplied to the enclosure was matched to the air quantity exhausted. The doors shown on the enclosure drawing were kept closed during dust sampling except as required to operate the draw frame and the samplers.

The supply-air unit was the same unit that was used in the isolated card tests and has been described previously.

Summary of the Test Data. Normal draw frame operation. Both enclosure doors closed, no exhaust or supply-air fans running.

Vertical Elutriator Samples (mg/m ³)				
<u>Date</u>	<u>Position #1</u>	<u>Position #2</u>	<u>Position #3</u>	<u>Position #4</u>
8/24/73	0.38	0.42	0.39	0.48
8/27/73	0.38	0.42	0.40	0.44
8/28/73	0.19	0.19	0.21	0.18
8/30/73	0.33	0.32	0.34	0.31
8/31/73	0.17	0.21	0.23	0.18
9/4/73	0.41	0.35	0.36	0.36
n =	6	6	6	6
\bar{x} =	0.31	0.32	0.32	0.33
σ =	0.10	0.10	0.08	0.13

Summary of the Test Data. (continued)

Positions #1, 2, 3 and 4 above combined.

n = 24 Minimum = 0.17
 \bar{x} = 0.32 Median = 0.35
 σ = 0.10 Maximum = 0.48

Date	OSHA General Area Samples (mg/m ³)		Stationary Personal Sampler (mg/m ³)	
	Position #5		Position #6	
8/27/73	0.93		0.60	
8/28/73	0.74		0.33	
8/30/73	2.37		0.89	
8/31/73	0.75		0.30	
9/4/73	0.88		0.73	

n = 5	Minimum = 0.74	n = 5	Minimum = 0.30
\bar{x} = 1.13	Median = 0.88	\bar{x} = 0.57	Median = 0.60
σ = 0.70	Maximum = 2.37	σ = 0.25	Maximum = 0.89

High-Volume Samples (mg/m³)

Date	Position #7									
8/27/73	3.37	5.73*	1.87	1.03	2.14					
8/28/73	2.28	2.13	2.56	3.59	1.57	4.59*	3.48	2.63	2.15	1.63
8/31/73	1.92	1.60	1.51	1.83	2.18	4.28*	1.91	1.49	1.51	1.87
9/4/73	2.37	2.21	4.64*	1.85	2.01					

* Collector unit cleaned out during test.

n = 30 Minimum = 1.03
 \bar{x} = 2.46 Median = 2.14
 σ = 1.12 Maximum = 5.73

On 9/5/73 the stock being processed on the test draw frame was changed. The specifications of the new stock mix were as follows:

Percentage	Description
50	Comber Noils
30	Flats Strips
20	Rayon

Shirley Analyzer data = 1.1% visible foreign matter, 1.3% invisible loss for 2.4% total loss.

Additional dust measurements with the new stock mix were made as follows:

Vertical Elutriator Samples (mg/m ³)		High Volume Samples (mg/m ³)	
Position 1, 2, 3 and 4 Combined		Position #7	
n = 8	Minimum = 0.30	n = 9	Minimum = 1.27
\bar{x} = 0.34	Median = 0.33	\bar{x} = 2.31	Median = 1.99
σ = 0.04	Maximum = 0.42	σ = 1.03	Maximum = 4.63

Summary of the Test Data. (continued)

The lint and dust discharged from the draw frame collector unit was then captured by a suction hood. See test facility drawing for location. Results of dust measurements were as follows:

Vertical Elutriator Samples (mg/m ³)				
Date	Position #1	Position #2	Position #3	Position #4
9/17/73	0.17	0.18	0.22	0.26
9/18/73	0.10	0.10	0.14	0.15
9/19/73	0.21	0.21	0.21	0.27
9/20/73	0.15	0.16	0.19	0.20
9/21/73	0.14	0.14	0.15	0.17
9/24/73	0.12	0.10	0.11	0.13
9/25/73	0.28	0.20	0.22	0.22
n =	7	7	7	7
\bar{x} =	0.17	0.16	0.18	0.20
σ =	0.06	0.04	0.04	0.05

Positions #1, 2, 3 and 4 above combined.

n = 28	Minimum = 0.10
\bar{x} = 0.18	Median = 0.17
σ = 0.05	Maximum = 0.28

Date	OSHA General Area Samples (mg/m ³)		Stationary Personal Sampler (mg/m ³)	
	Position #5		Position #6	
9/17/73	0.43		0.26	
9/18/73	0.42		0.18	
9/19/73	0.36		0.35	
9/20/73	0.35		0.35	
9/21/73	0.32		0.21	
9/24/73	0.25		0.28	
9/25/73	0.45		0.39	
n = 7	Minimum = 0.25		n = 7	Minimum = 0.18
\bar{x} = 0.37	Median = 0.36		\bar{x} = 0.29	Median = 0.28
σ = 0.07	Maximum = 0.45		σ = 0.08	Maximum = 0.39

High Volume Samples (mg/m ³)									
Date	Position #7								
9/17/73	1.08	0.93	0.64	0.86	1.38	1.07	0.62	1.24	0.88
9/18/73	2.33*	0.61	0.72	0.64	0.98	1.37	0.82	0.89	1.21

* Collector unit cleaned out during test.

n = 18	Minimum = 0.61
\bar{x} = 1.02	Median = 0.91
σ = 0.41	Maximum = 2.33

Summary of the Test Data. (continued)

The next series of tests consisted of adding a suction hood over the sliver guide zone of the draw frame creel. The lifting rolls of this creel were not power driven. The bottom of the hood was located one foot above the sliver guides. The hood was six feet long and four feet wide at the bottom. These tests were run with the hood handling an air quantity of 1500 cfm.

Since the combined air quantities of the hood over the collector unit discharge (1600 cfm) and the hood over the creel (1500 cfm) exceeded the capacity of the air supply unit used in the earlier tests, an additional source of air supply to the enclosure was necessary. It had originally been planned to use the air supply unit installed at Mill Code 28 for the isolated comber tests for this purpose. However, at the time of these tests, that unit was being used for other purposes and was not available. Therefore it was decided to use double-filtered outside air for make up. See the second facility drawing that follows for arrangement.

Results of dust measurements were as follows:

Vertical Elutriator Samples (mg/m ³)				
Date	Position #1	Position #2	Position #3	Position #4
10/5/73	0.20	0.21	0.15	0.16
10/8/73	0.13	0.17	0.16	0.14
10/9/73	0.13	0.13	0.11	0.10
10/10/73	0.20	0.18	0.16	0.19
10/11/73	0.21	0.23	0.26	0.21
n =	5	5	5	5
\bar{x} =	0.17	0.18	0.17	0.16
σ =	0.04	0.04	0.06	0.04

Positions #1, 2, 3 and 4 above combined.

n = 20	Minimum = 0.1
\bar{x} = 0.17	Median = 0.17
σ = 0.04	Maximum = 0.26

Date	OSHA General Area Samples (mg/m ³)	Stationary Personal Sampler (mg/m ³)	
	Position #5	Position #6	
10/5/73	0.38	0.21	
10/8/73	0.39	0.37	
10/9/73	0.35	0.40	
10/10/73	0.41	0.18	
10/11/73	-	0.63	
n = 4	Minimum = 0.35	n = 5	Minimum = 0.18
\bar{x} = 0.38	Median = 0.39	\bar{x} = 0.36	Median = 0.37
σ = 0.03	Maximum = 0.41	σ = 0.18	Maximum = 0.63

High volume samples were taken in the discharge duct of the air supply units also. These results were:

Date	High Volume Samples in Air Supply Unit Discharge (mg/m ³)
10/5/73	0.11
10/8/73	0.10

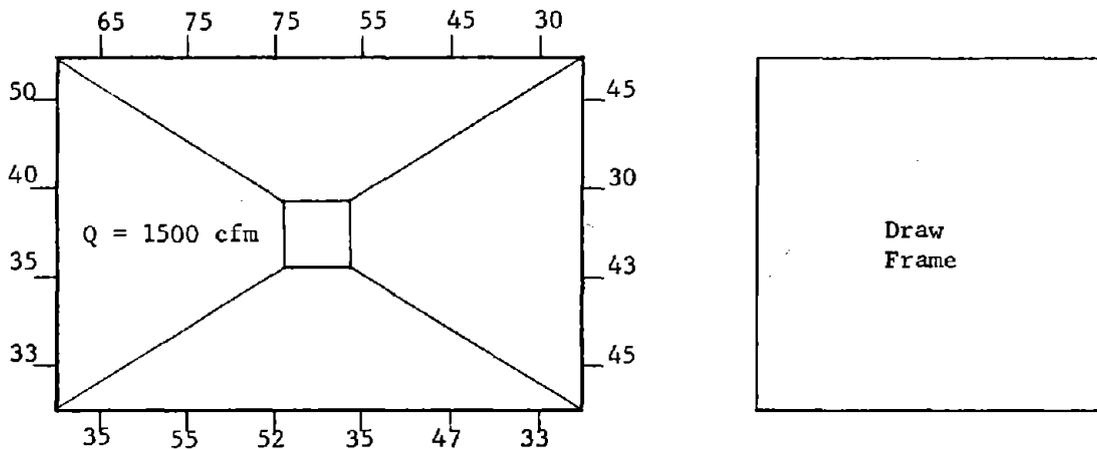
Summary of the Test Data. (continued)

<u>Date</u>	<u>High Volume Samples in Air Supply Unit Discharge (mg/m³)</u>
10/9/73	0.07
10/10/73	0.08
10/11/73	0.09

n = 5 Minimum = 0.07
x = 0.09 Median = 0.09
σ = 0.02 Maximum = 0.11

Hot-Wire Anemometer Readings

Velocity readings (fpm) around the lower perimeter of the suction hood over the draw frame creel, six inches below the bottom flange were measured as shown in the sketch below:



Fibrograph Analysis

The quantity of lint in the waste collected by the suction hoods in all of the above described tests was extremely small. The waste consisted mainly of fine dust particles with a small percentage of very short fibers. Therefore, this waste was not appropriate for Fibrograph analysis since none of it could have been considered spinnable.

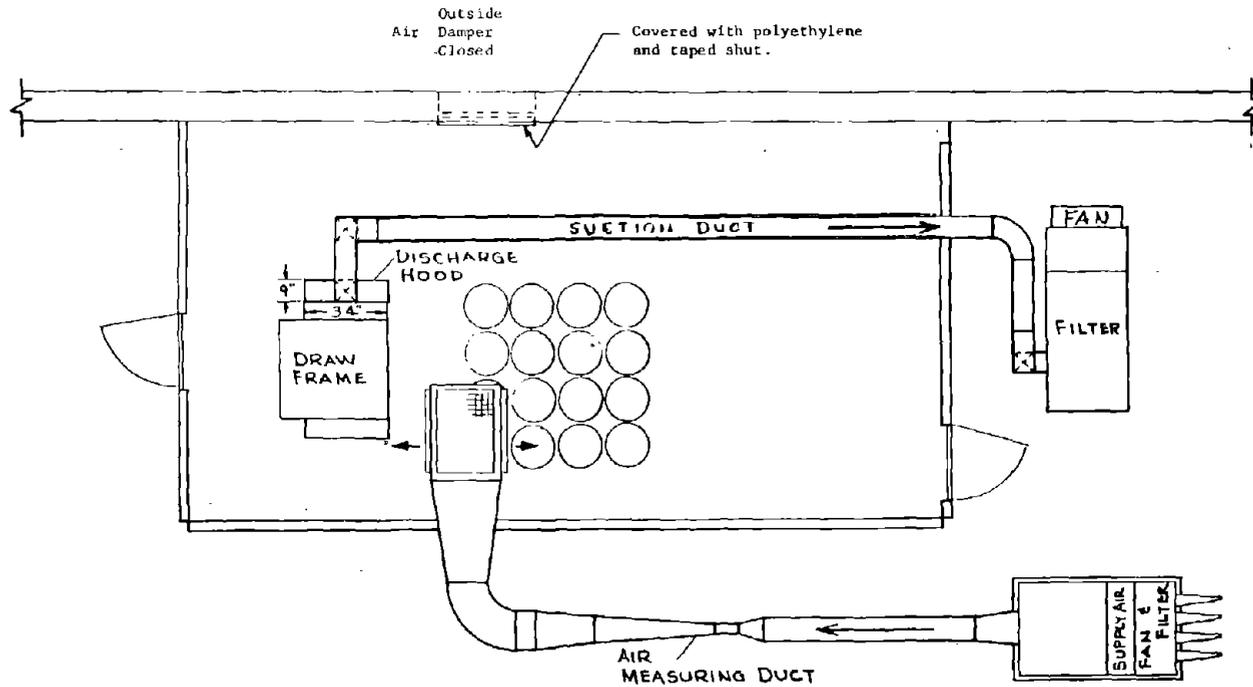
Comments and Conclusions. All of the vertical elutriator dust concentration readings with normal operation of the draw frame were under 0.5 mg/m^3 . The mean dust concentration was 0.32 mg/m^3 , the median 0.35 mg/m^3 and the maximum was 0.48 mg/m^3 . Thus, indicating that a modern high speed draw frame may not require external lint and dust control devices.

When the lint and dust that did escape the collector unit discharge was captured, the mean dust concentration in the worker's environment were reduced as follows:

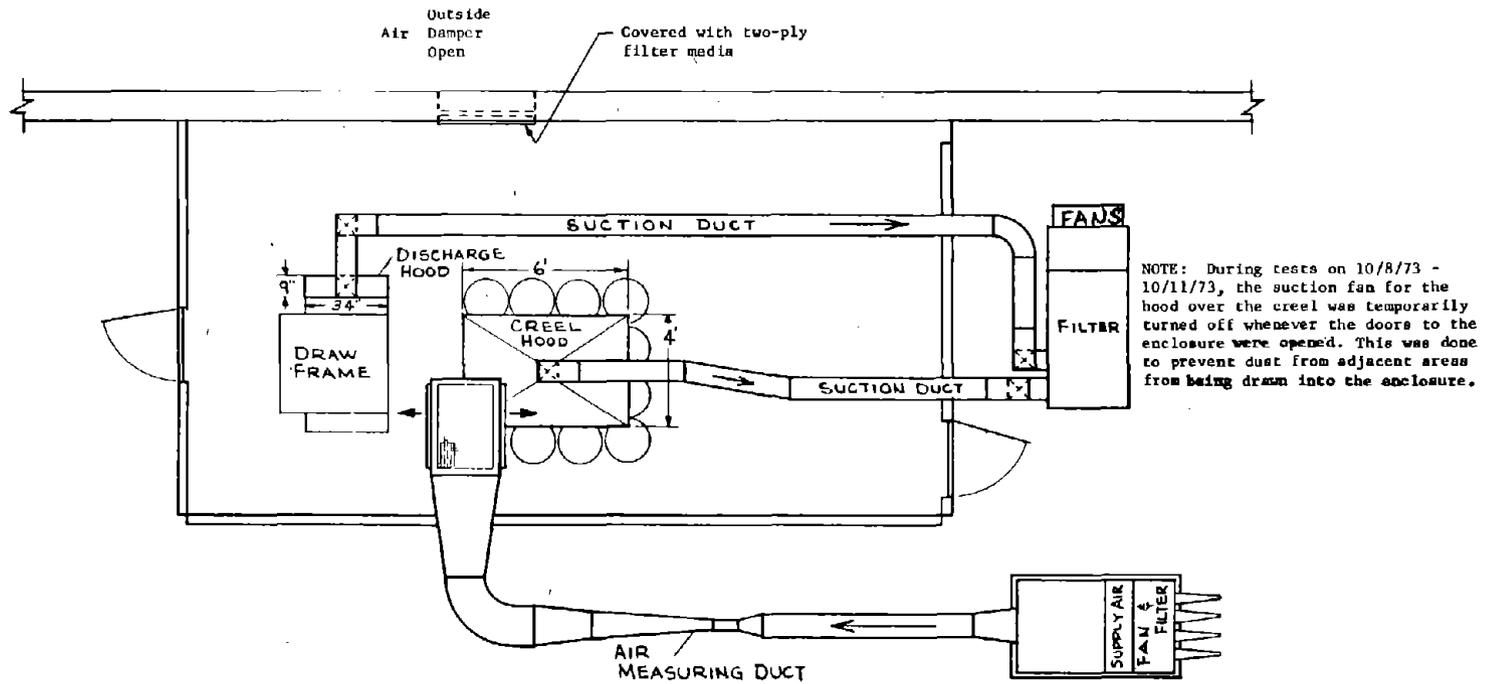
<u>Sampling Instrument</u>	<u>Mean Dust Concentration (mg/m^3)</u>		<u>% Reduction</u>
	<u>Normal Operation</u>	<u>Capturing Discharge</u>	
High-Volume	2.46	1.02	58.5
OSHA Area	1.13	0.37	67.3
Stationary Personal	0.57	0.29	49.1
Vertical Elutriator	0.32	0.18	43.8

Comparison of the mean dust concentration after the hood was added over the creel with the above indicates no significant reduction. This should not be interpreted to mean that such devices may not be required for draw frames equipped with power driven creels, especially if dust concentrations of 0.2 and 0.1 mg/m^3 as measured by the vertical elutriator were to be maintained. From observation of the hood which was tested, it was apparent that the addition of baffles or side panels, essentially enclosing the upper portion of the creel, would have improved the capture of this hood.

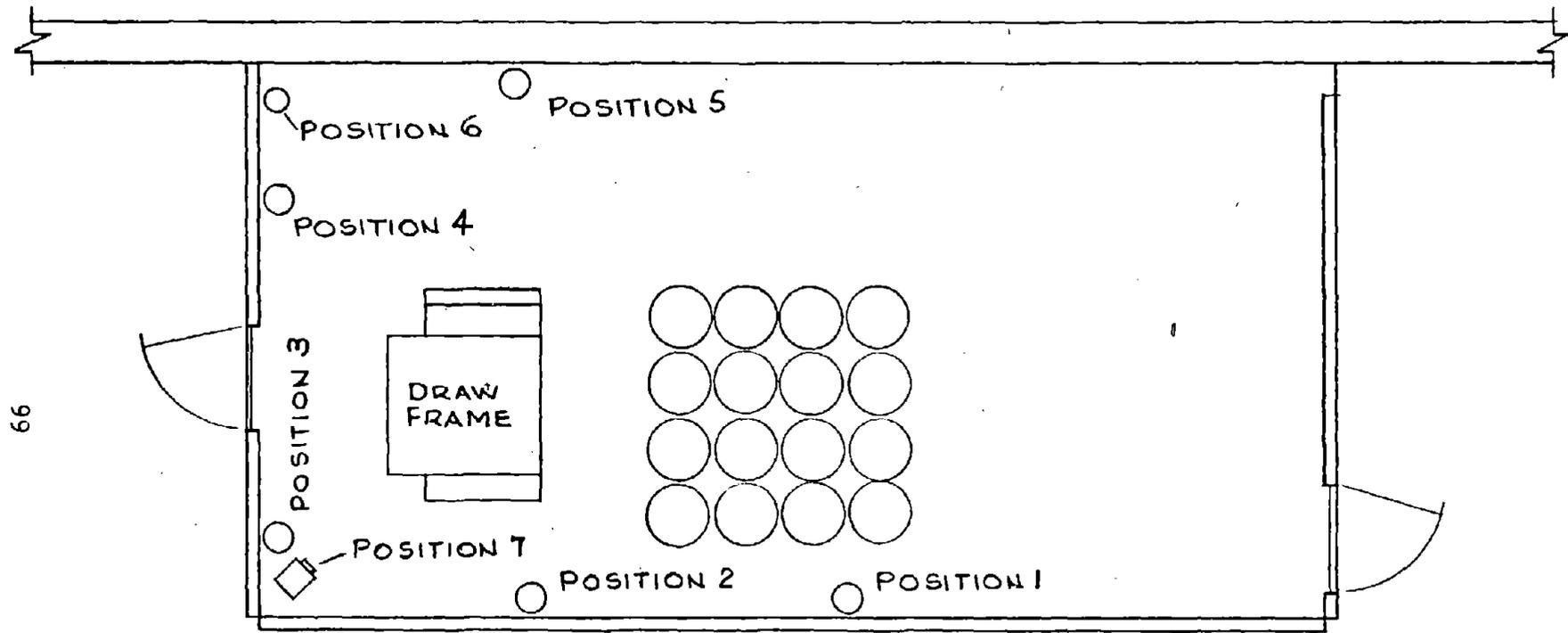
In the summary of the test data at the top of p. 94, it is stated, "The lifting rolls of this creel were not power driven." Actually, this creel was not equipped with lifting rolls, but with sliver guides. This is to emphasize to the reader that this creel was not power driven.



TEST FACILITY - ISOLATED DRAW FRAME
MILL CODE 38
WITH SUCTION HOOD OVER DISCHARGE OF COLLECTOR UNIT



TEST FACILITY - ISOLATED DRAW FRAME
 MILL CODE 38
 WITH SUCTION HOOD OVER DISCHARGE OF COLLECTOR UNIT
 AND OVER CREEP



MILL CODE 38

SAMPLER LOCATION-ISOLATED DRAW FRAME

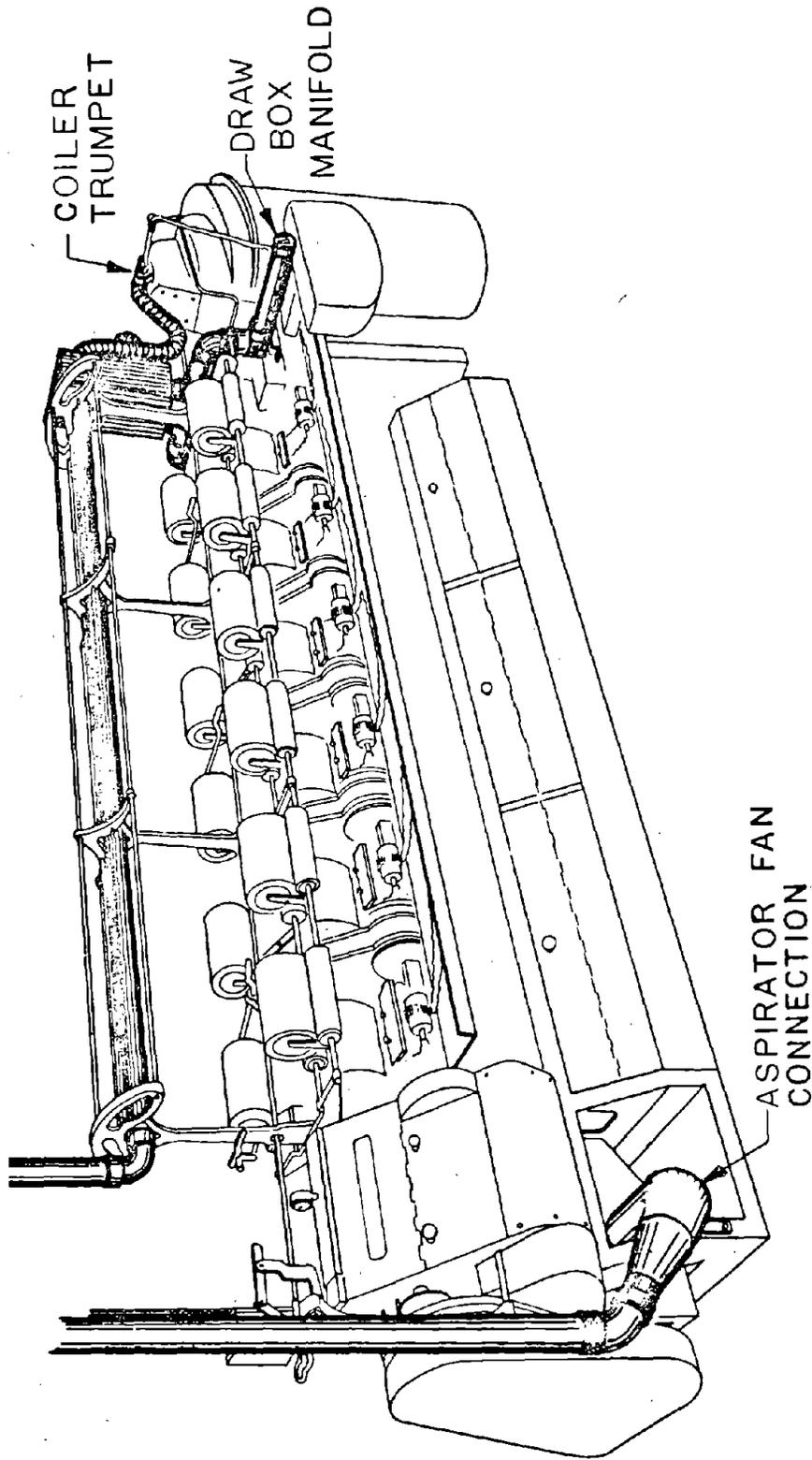
Description
Lint and Dust Capture Devices for Combers

Most fly and dust generated by a comber comes from the aspirator fan which (on most combers now in service) discharges directly into the room environment at each comber. A duct connection to the fan aspirator exhaust accomplishes positive capture of this dust.

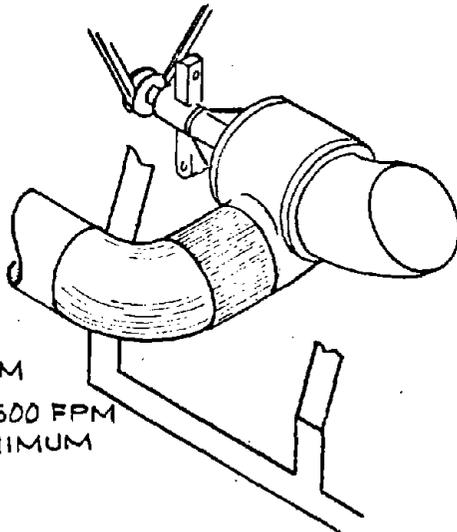
At the coiler the dust problem is the same as on cards except that a lesser quantity of dust can be expected.

The draw box generates fly and dust similar to all other drafting systems. Quantity from the comber, however, should be less than from drawing frames. A small air quantity which can be economically handled through the manifold shown on the drawings controls this dust and the manifold is mounted so that it can be moved out of the way for necessary piecing up and other operations around the draw box.

For control of dust around combers to a level not exceeding 0.5 mg/m³ as measured by the vertical elutriator air quantities of 500 to 700 cfm will be required.



COMBER SUCTION ATTACHMENTS

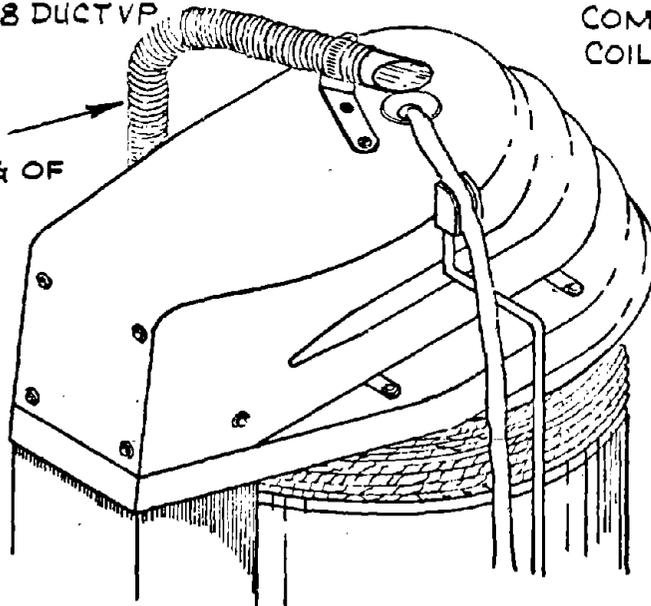


COMBER
ASPIRATOR FAN
DISCHARGE CONNECTION

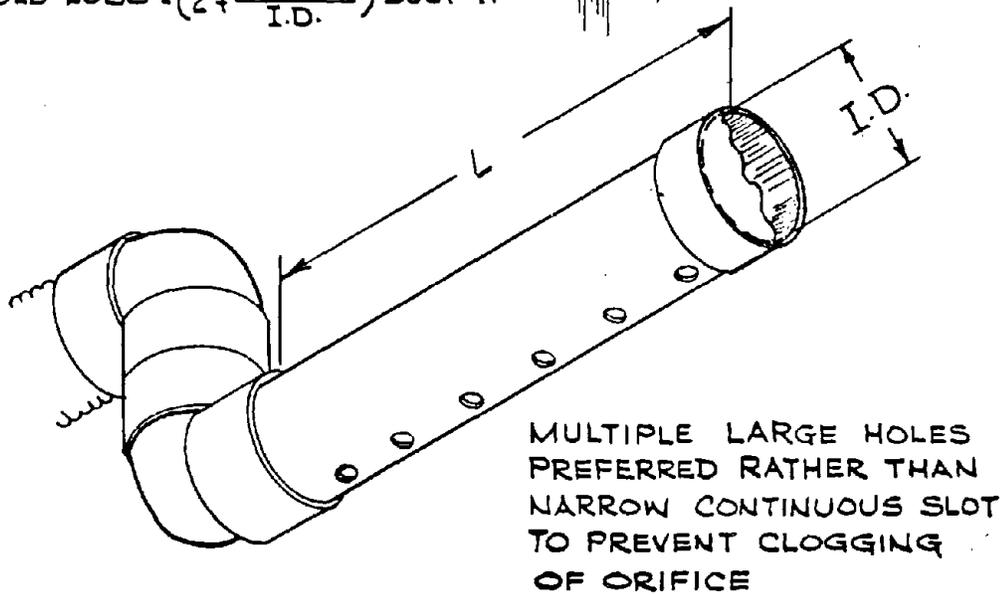
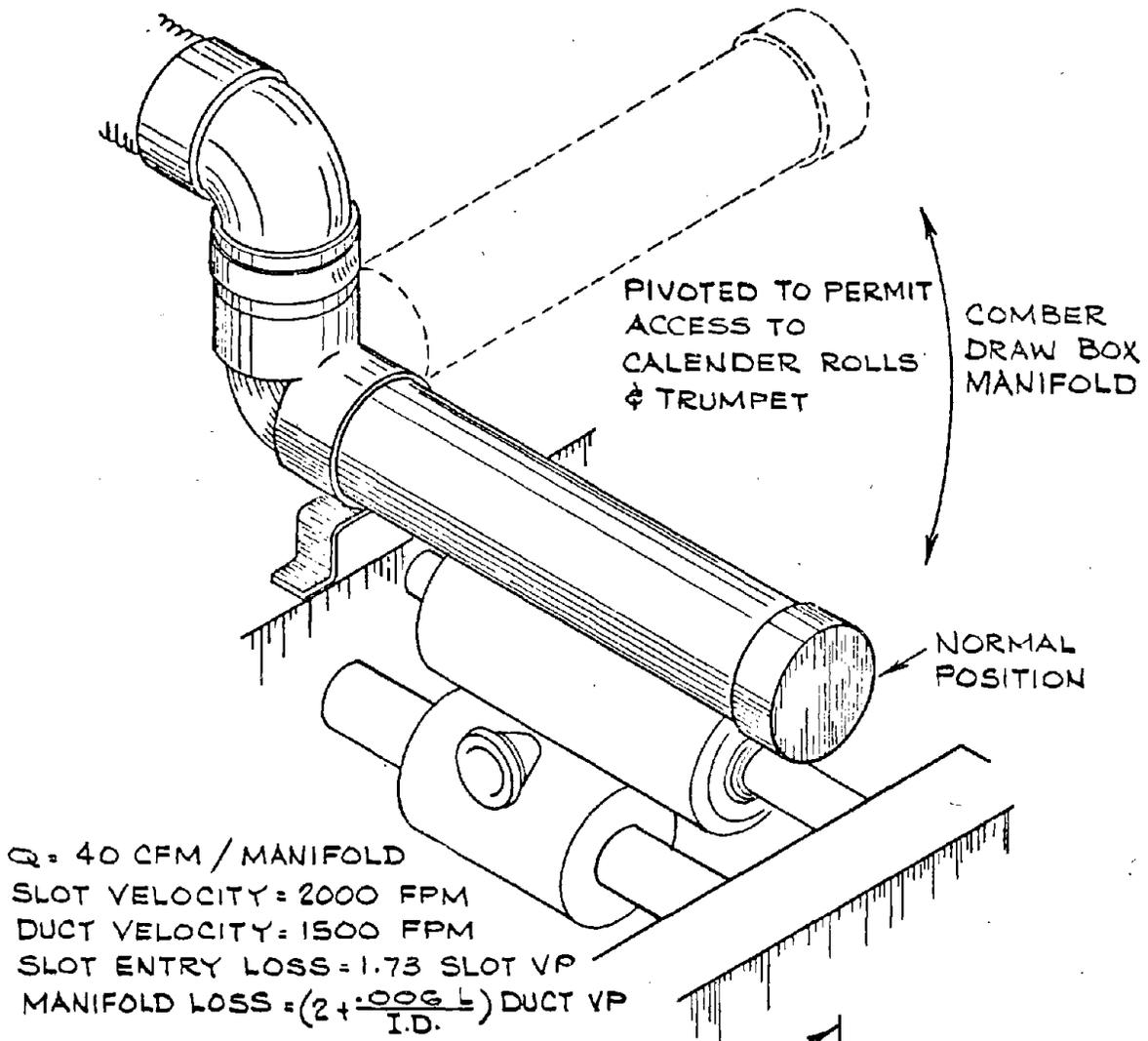
Q = 350 - 500 CFM
DUCT VELOCITY = 1500 FPM
MINIMUM
ENTRY LOSS = 0

Q = 40 CFM / COILER
DUCT VELOCITY = 2000 FPM
ENTRY LOSS = 1.8 DUCT VP

FLEX DUCT TO
ALLOW RAISING OF
COILER HEAD



COMBER
COILER TRUMPET



Dust Control System on Combers
at
Mill Code #26

Mill Code 26 manufactures high quality wearing apparel fabric from 1-3/32" middling cotton.

Production Machinery Specifications and Arrangement. The comber installation consisted of 30 Saco-Lowell combers (nine model 50, seven model 52, ten model 54, two model 56, and two model 57). These combers operated at 110 nips per minute, producing a 59 grain sliver with 10½% noils removed at the rate of 309 pounds per 8 hours per comber. As shown on the drawing that follows, they were arranged in a group of 5 rows wide by 6 combers per row long. In addition, there were 3 machines which were not equipped for dust control. The comber area was bounded by a wall along one side and by draw frames on the other three sides. All of the production machinery in the adjacent areas was operating during the comber dust sampling procedures.

Lint and Dust Capture System. This equipment was designed to control the visible lint and dust only. It represented a typical comber dust control problem and the capture system was like that previously explained. Each comber was equipped with a three-point suction cleaning system consisting of a manifold at the top calender roll of each draw box, a suction tube at the coiler head trumpet of the two coilers and a duct connection at the aspirator fan discharge. Air quantity per machine was as follows:

	<u>Average CFM</u>
Aspirator fan discharge connection (determined by pitot traverse)	464
Coiler trumpet (2 @ 50 cfm each) (determined by calibrated pressure tap)	100
Draw box manifold (2 @ 41 cfm each) (determined by calibrated pressure tap)	<u>82</u>
Total per comber	646

Duct, Filter and Return Air System. The dust and lint collected by the suction attachments on the combers was ducted to three branch lines serving 10 combers per branch. The three branch lines joined into one main trunkline to one central filter fan unit located at the end of the comber area. The filter is described in some detail on the drawing that follows. This plant was air conditioned but the filtered air was not returned to the air conditioning system. Instead it was returned directly to the area occupied by the combers through an overhead diffuser duct.

Summary of the Test Data. (Samples taken from 8/15/72 to 10/6/72)

Vertical Elutriator Samples (mg/m³)

	Location #1	Location #2	Location #3	Location #4
n =	17	20	20	18
\bar{x} =	0.12	0.10	0.14	0.14
σ =	0.02	0.03	0.03	0.03

Summary of the Test Data. (Samples taken from 8/15/72 to 10/6/72) ... continued

Vertical Elutriator Samples (mg/m³)

	Location #1	Location #2	Location #3	Location #4
Minimum =	0.07	0.07	0.09	0.07
Median =	0.12	0.10	0.135	0.14
Maximum =	0.17	0.21	0.21	0.21

Vertical Elutriator Samples - All Locations (mg/m³)

n =	75	Minimum =	0.07
\bar{x} =	0.125	Median =	0.12
σ =	0.034	Maximum =	0.21

Filter Efficiency Analysis - High Vol Samples (mg/m³)

	"Dirty" side of the filter (with #16 mesh lint screen ahead of the dust filter)	"Clean" side of the filter - in the discharge duct
n =	38	11
\bar{x} =	3.8	0.18
σ =	1.4	0.12
Minimum =	1.94	0.002
Median =	3.5	0.15
Maximum =	8.37	0.38

$$\text{Filter Efficiency} = (3.8 - 0.18) \times 100 / 3.80 = 95\%$$

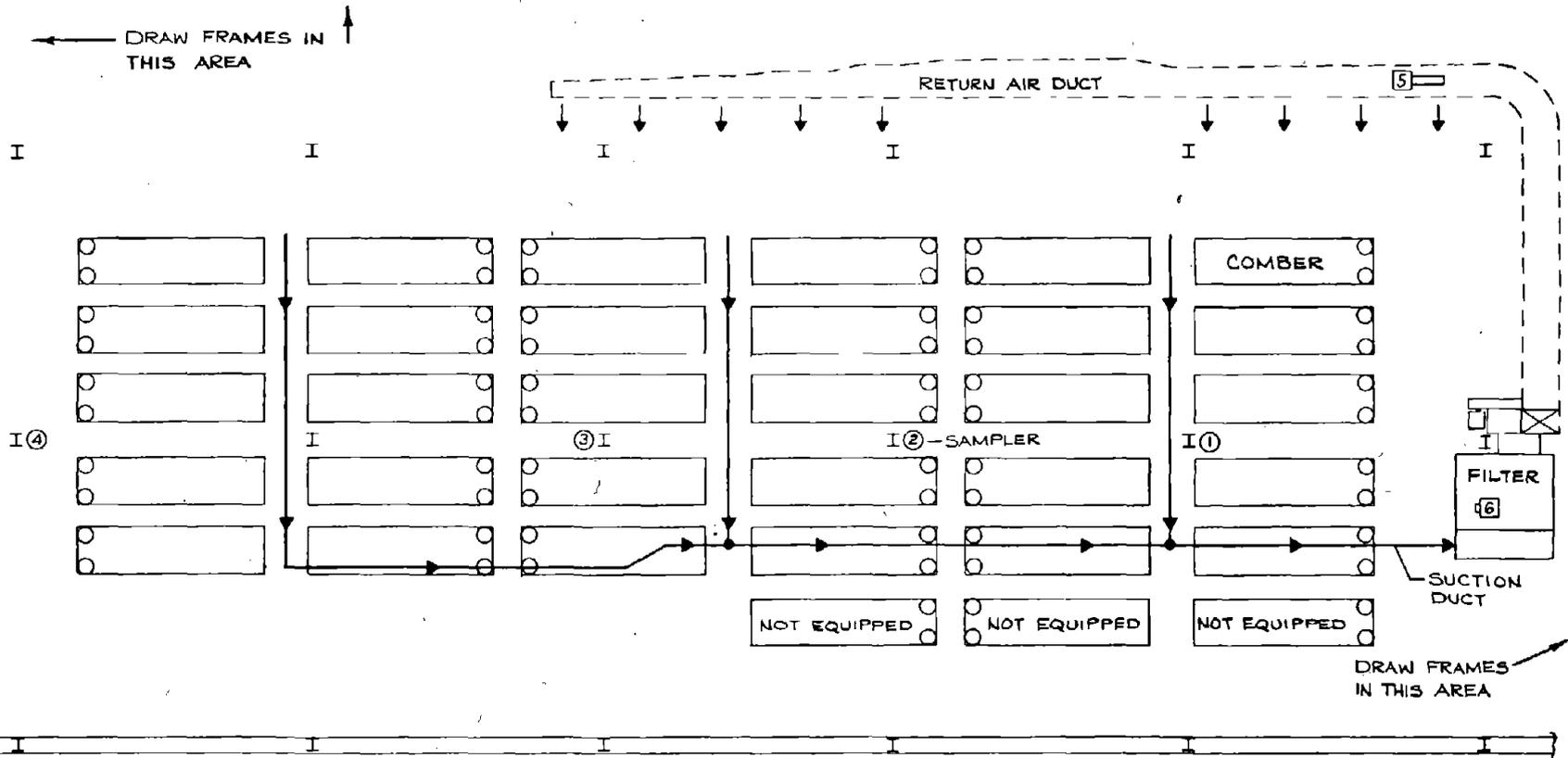
Comments and Conclusions. This was a thorough test with a large number of samples taken through the center of the area. The readings were remarkably consistent with a ratio of only 3 to 1 between minimum and maximum figures.

This was not a controlled test. All of the samples were taken in a cotton textile plant, in full production, for three shifts per day and the readings were spread out over a period of almost two months.

Combers always operate on relatively high quality stock. Therefore, little variation can be expected in the dust control problem from one mill to another. Also, the dust control equipment was minimal with only one stage of filtration. It should be noted that the filter was properly maintained in this plant.

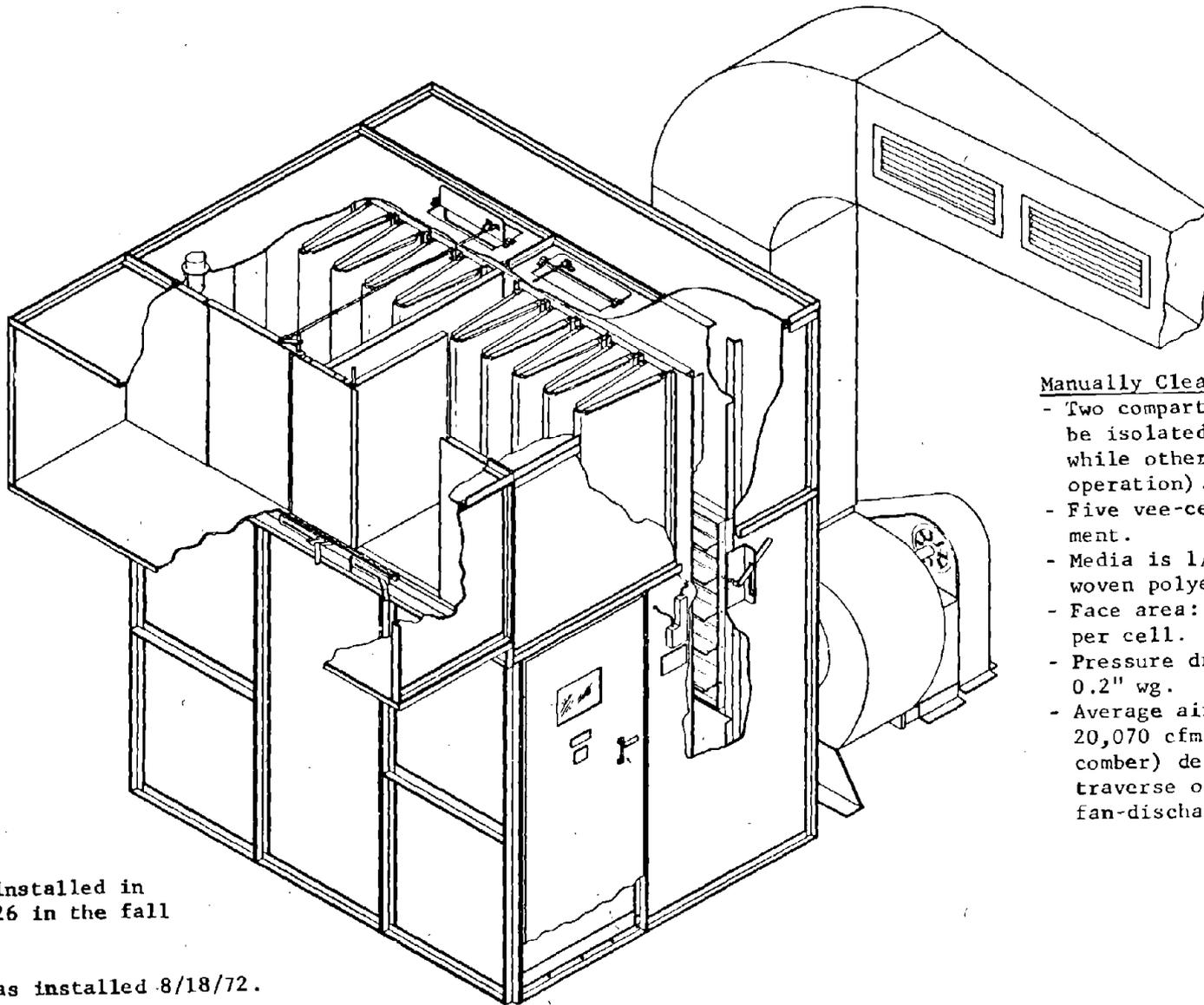
It can be concluded from these data, therefore, that combers can be consistently controlled to about the dust levels shown in these figures.

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MILL CODE # 26
COMBER SYSTEM LAYOUT
 DRAWING # 10062-1

- VERTICAL ELUTRIATOR (NUMBER IN CIRCLE IS POSITION NUMBER)
- HI VOLUME SAMPLER



Manually Cleaned Filter

- Two compartments (one can be isolated and cleaned while other remains in operation).
- Five vee-cells per compartment.
- Media is 1/2" thick non-woven polyester.
- Face area: 31.2 ft² per cell. 312 ft² total.
- Pressure drop clean is 0.2" wg.
- Average air quantity is 20,070 cfm (669 cfm per comber) determined by pitot traverse of central-filter-fan-discharge duct.

Filter was installed in Mill Code #26 in the fall of 1968.

New media was installed 8/18/72.

Isolated Comber
at
Mill Code #28

Mill Code 28 is a textile laboratory. The objective of this project included studies of an isolated card, comber and draw frame. The facilities of Mill Code 28 offered an ideal arrangement for the isolated card and comber tests. Equipment was set up for testing both machines. However, other assignments of the laboratory precluded testing the card here and it was necessary to duplicate the facilities for testing that machine in another location.

Most of the testing on the comber was on Pima cotton of 1-5/16" to 1-3/8" staple, 60% middling spot and 39% strict low middling. A Shirley Analyzer test of the comber lap showed a visible foreign matter content of 0.1% and an invisible loss of 0.5%.

After completion of the Pima cotton testing, a short test was arranged on a lower grade stock. This was 1-1/16" staple, 50% strict good ordinary and 50% low middling. A Shirley Analyzer test on the comber lap showed a visible foreign matter content of 0.7%, and an invisible loss of 0.3%.

Production Machinery Specifications. This single comber at Mill Code 28 was a Saco-Lowell model 56. On the Pima cotton test, it was operated at a production rate of 55 pounds per hour at 120 nips per minute with 14% noils, making a 53 grain sliver from an 806 grain lap.

On the test for the lower grade cotton, it was operated at a production rate of 52 pounds per hour at 120 nips per minute with 15% noils, making a 50.7 grain sliver from an 806 grain lap.

Lint and Dust Capture System. This equipment was designed to control the visible lint and dust only, and the capture system is like that previously explained. Each comber was equipped with a 3 point suction cleaning system consisting of a manifold at the top calender roll of each draw box, a suction tube at the coiler head trumpet of the two coilers, and a duct connection at the aspirator fan discharge. Air quantity was as follows:

	<u>CFM</u>
Aspirator fan discharge connection (determined by pitot traverse)	350
Coiler trumper (2 @ 45 cfm each - determined by calibrated pressure tap)	90
Draw-box manifold (2 @ 45 cfm each - determined by calibrated pressure tap)	<u>90</u>
Total	530

Duct, Filter and Return Air System. Please see the test facility drawing. Suction was applied to the lint and dust capture devices by a simple suction duct to a small fan-filter unit which discharged outside the comber enclosure. The suction air quantity was matched by a special supply-air arrangement consisting of a first stage "V" type filter with a second stage electrostatic precipitator, a supply-air fan, an air measuring duct with a discharge diffuser to return air to the comber enclosure. The comber lint and dust capture system was thus isolated from outside influence and dust level measurements inside the comber enclosure should measure the efficiency of the capture system only.

Summary of the Test Data. Pima Cotton, Vertical Elutriator Samples (mg/m³).
 Samples taken from 12/13/72 to 1/19/73. Lint and dust control system operating.

	Position #1	Position #2	Position #3	Position #4
n =	7	7	7	7
\bar{x} =	0.082	0.058	0.114	0.073
σ =	0.039	0.042	0.041	0.022

- Positions 1, 2 and 3 combined (mg/m³)

n =	21	Minimum = 0.019
\bar{x} =	0.090	Median = 0.087
σ =	0.041	Maximum = 0.170

Pima Cotton High Volume Samples (mg/m³). Sample taken 1/30/73. Lint and dust control system operating.

Position #6 = 0.20

* Pima Cotton, Vertical Elutriator Samples (mg/m³). Samples taken 1/31/73. Lint and dust control system not operating. For sampler locations, see "Dust Sampler Positions - Tests on Lower Grade Cotton".

	Positions 1, 2 and 3 combined
Position #1 = 1.79	n = 3
Position #2 = 1.38	\bar{x} = 1.46
Position #3 = 1.21	σ = 0.30
Position #5 = 0.18	

* Pima Cotton, High Volume Samples (mg/m³). Samples taken 1/31/73. Lint and dust control system not operating. For sampler locations, see "Dust Sampler Positions - Tests on Lower Grade Cotton".

Position #6	n = 7	Minimum = 3.28
	\bar{x} = 4.47	Median = 4.02
	σ = 1.02	Maximum = 6.16

Lower Grade Cotton, Vertical Elutriator Samples (mg/m³). Samples taken 3/5/73. Lint and dust control system operating.

	Positions 1, 2 and 3 combined
Position #1 = 0.046	n = 3
Position #2 = 0.051	\bar{x} = 0.061
Position #3 = 0.086	σ = 0.022
Position #5 = 0.115	

Lower Grade Cotton, High Volume Samples (mg/m³). Samples taken 3/5/73. Lint and dust control system operating.

Position #6	n = 5	Minimum = 0.17
	\bar{x} = 0.20	Median = 0.19
	σ = 0.02	Maximum = 0.22

* - These data were not for Pima Cotton. Please see "Comments and Conclusions" for explanation.

Lower Grade Cotton, Vertical Elutriator Samples (mg/m^3). Samples taken 3/6/73. Lint and dust control system not operating.

Position #1 = 0.28	n =	Positions 1, 2 and 3 combined
Position #2 = 0.40	\bar{x} =	3
Position #3 = 0.25	σ =	0.31
Position #5 = 0.07		0.079

Lower Grade Cotton, High Volume Samples (mg/m^3). Samples taken 3/6/73. Lint and dust control system not operating.

Position #6	n = 7	Minimum = 1.62
	\bar{x} = 2.28	Median = 2.19
	σ = 0.58	Maximum = 3.14

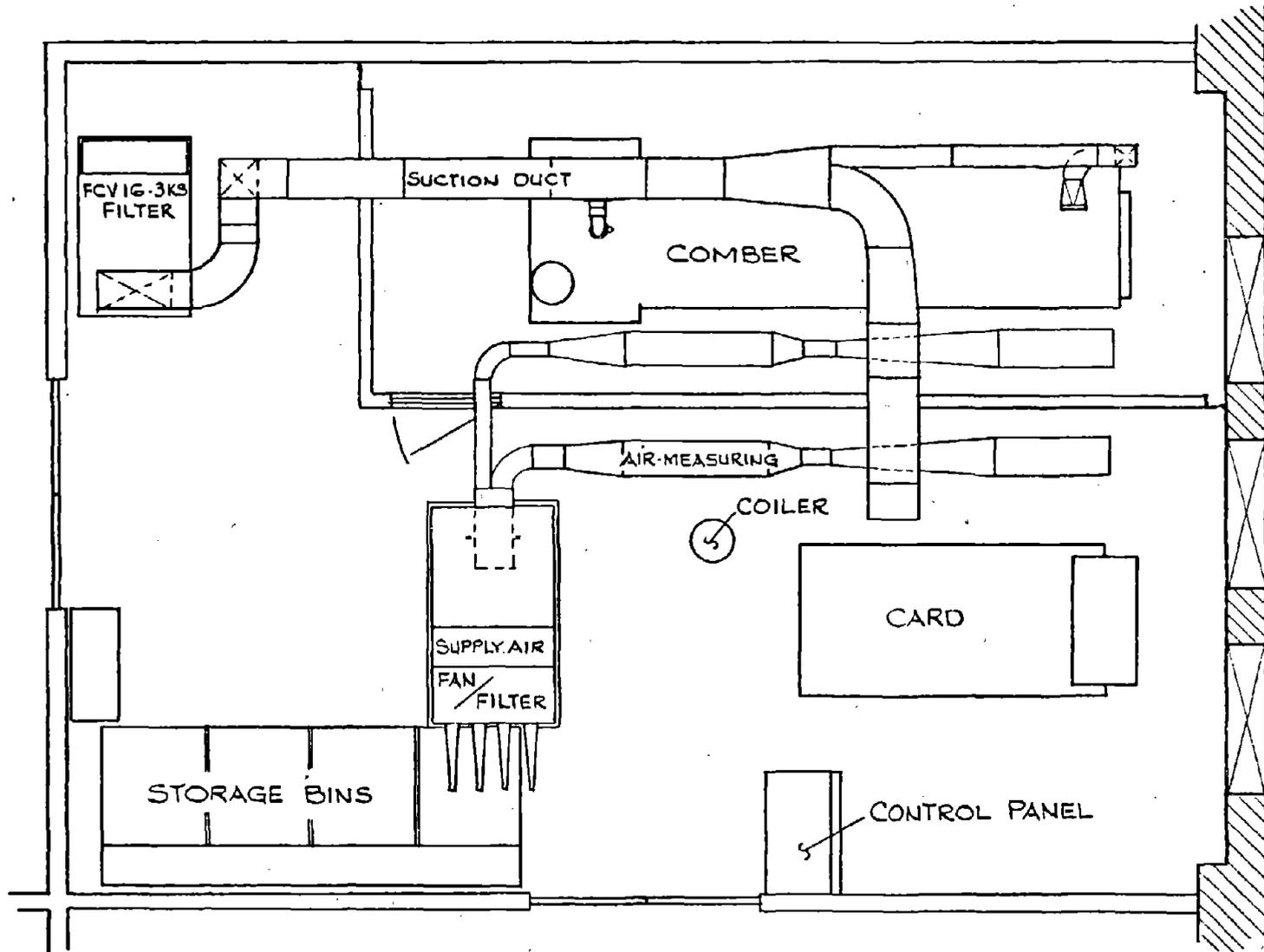
Comments and Conclusions. The data above marked by the asterick was not for Pima cotton as described. It was discovered long after the tests were concluded that there was a change in the cotton grade between the testing with the dust control system operating and the later test with the system not in operation. In the latter test the cotton was American Egyptian - 3, strict low middling, 1-7/16" staple.

The median dust level achieved by the dust capture system in these tests was less than 0.1 and the maximum was less than 0.2 mg/m^3 (vertical elutriator).

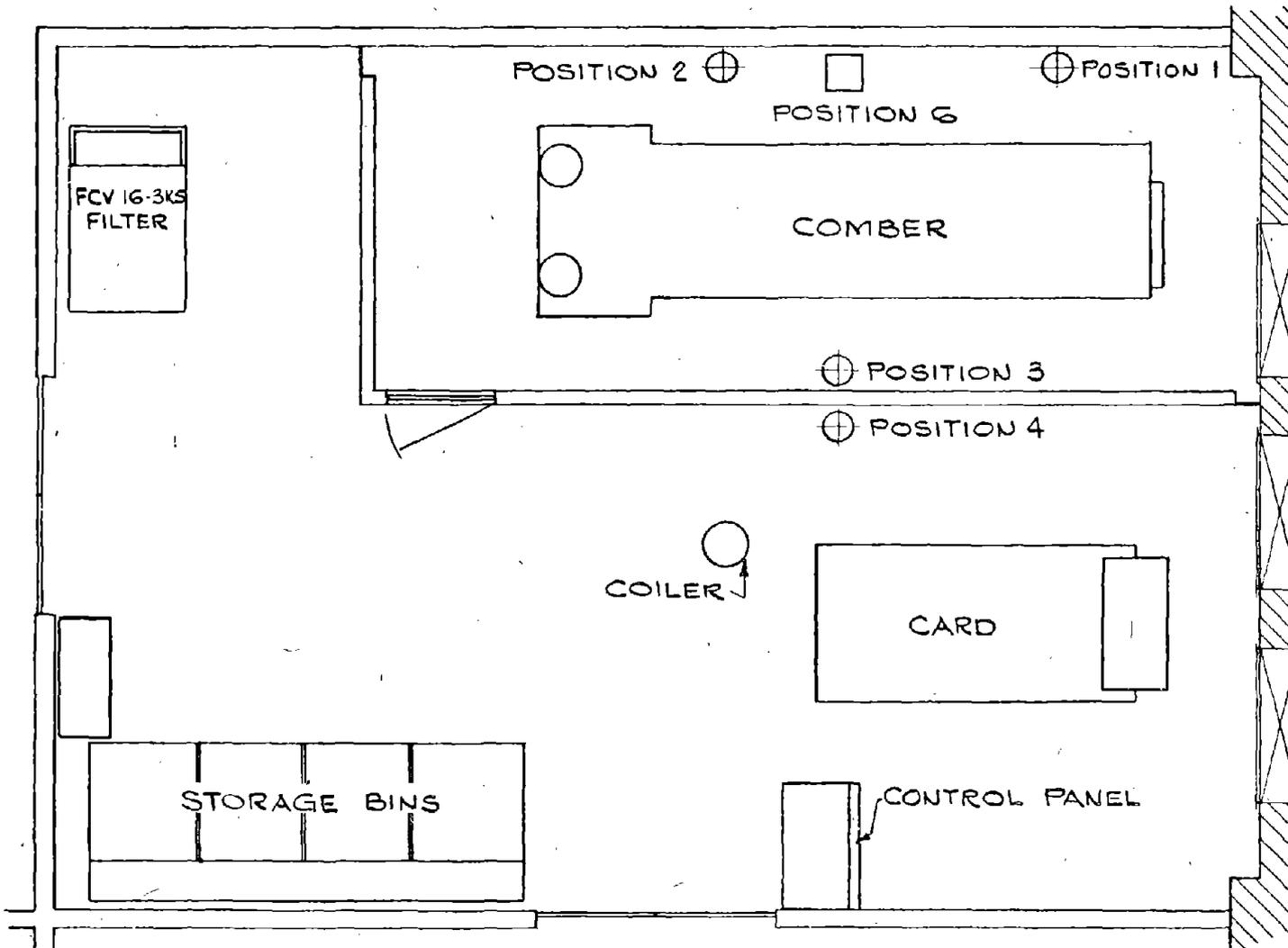
Using the average measured dust levels (vertical elutriator) and ignoring the mixup in cotton grades described above, the data shows a decrease of 93.8% in the dust level in the Pima cotton test and 80% with the lower grade cotton.

If additional air quantity is required to control extreme dust generation problems on combers, the logical location to add suction devices would be under and along the length of the sliver table. This would add vacuum collection of dust along the length of the functional area of the machine.

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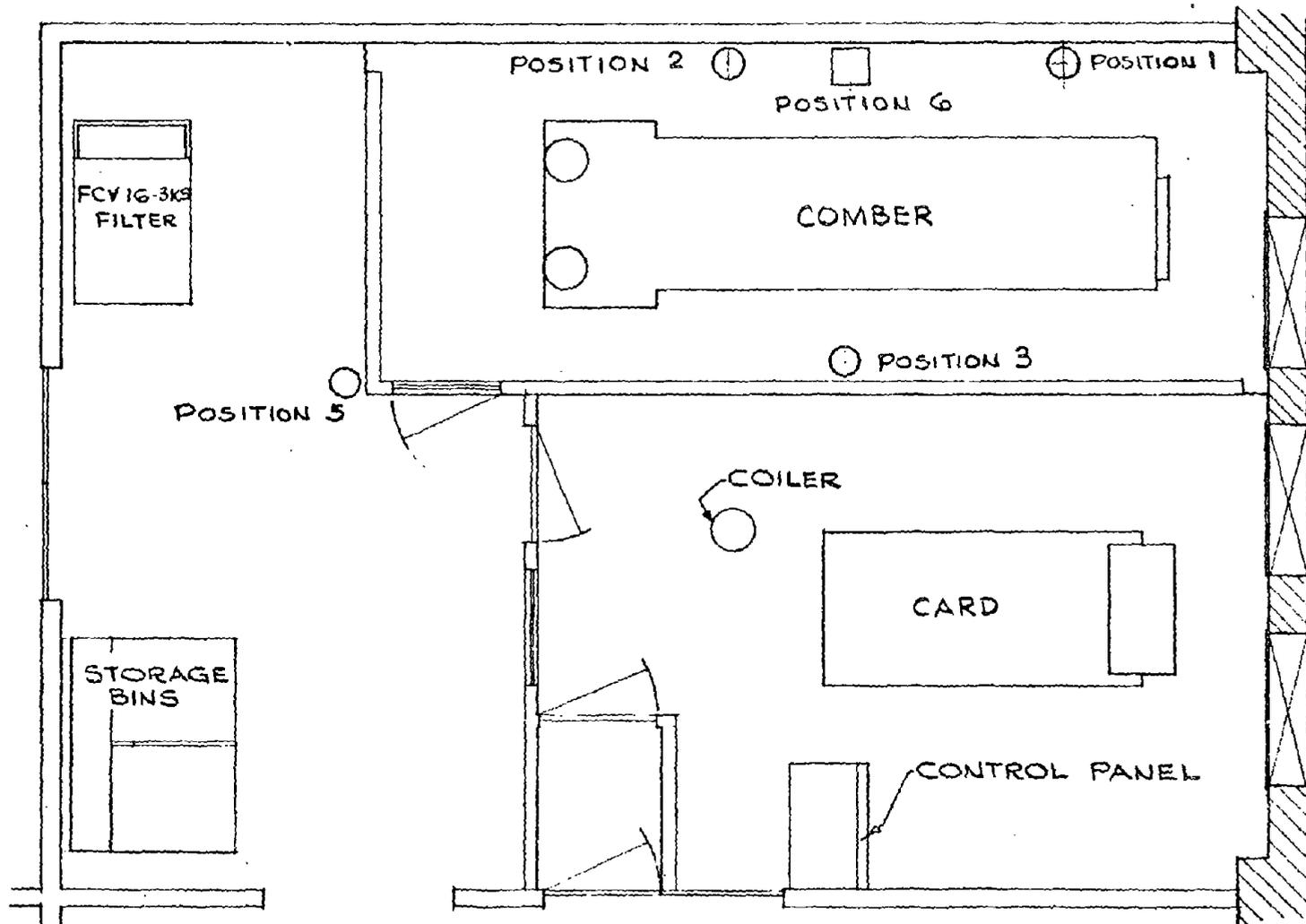
Mill Code #28
Test Facility - Isolated Comber



Comber - Mill Code #28
Dust Sampler Positions
Pima Cotton Tests

- = High Volume Sampler
- = Vertical Elutriator

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Comber - Mill Code #28
Dust Sampler Positions
Tests on Lower Grade Cotton

□ = High Volume Sampler
○ = Vertical Elutriator

A Technical Review
of
Cotton Dust and Air Filters

I. The Problem

A. INTRODUCTION

1. Properties of Particles

The three most important parameters in assessing the ability of an air cleaner to remove particles are particle size, shape and density. Particle size; because, in general, large particles settle more rapidly than small ones; density, because heavy ones fall faster than light ones; and shape, because particle shape can make either of the two preceding generalizations false. For the same amount and density of material, a teardrop shaped particle will fall faster than a sphere or more simply, a sheet of paper falls faster when rolled up into a ball.

In assessing the relative hazard of a collection of small particles these same factors are still important not only for gravitational settling but also for the phenomena of impaction and diffusion, and the same generalizations about particle size, shape and density still hold. The deposition of a particle in the human respiratory system is strongly dependent on these aerodynamic properties, which are often described in terms of the so-called "aerodynamic diameter" of the particle; the size of a unit density sphere which has the same terminal settling velocity as the particle in question.

It is generally agreed that unit density particles having aerodynamic diameters in excess of about 10 microns do not represent a respirable hazard. They are too large to penetrate into the deeper portions of the lung. Thus only those particles with aerodynamic diameters below 10 microns are considered to represent an inhalation hazard and are accordingly termed "respirable."

In the case of fibers, it is not as easy to generalize about which fibers are respirable or non-respirable. The shape of a fiber has a marked effect on its overall aerodynamic behavior. For example, studies by Timbrell (1) and Stober (2) have shown that aerodynamic diameter increases only slightly with increasing fiber length, depending mainly on the fiber diameter. This means that a series of fibers of different lengths, and hence different masses, will have approximately the same aerodynamic diameters if they all have approximately the same cross-sectional area. Thus extremely long fibers with quite small cross-sections can be considered to be respirable particles. On the other hand, shorter fibers with larger cross-sections may not be respirable. For asbestos fibers with length-to-diameter ratios (aspect ratios) between 10 and 100 a fiber will have an aerodynamic diameter roughly three to four times its fiber diameter. There is very little similar data for other fibrous materials. Some limited data by Timbrell (1) indicates a similar observation for glass fibers, except that the ratio of aerodynamic diameter to fiber diameter is closer to 3. In both cases this ratio increases very weakly with increasing aspect ratio.

It is not known whether a similar ratio exists for cotton fibers. The lower density of cotton, compared to either asbestos or glass fibers, would imply that the fiber diameter and the aerodynamic diameter should be about the same. On the other hand, it might be expected that since cotton fibers are not straight but may be twisted and spiraled, the fibers could begin to approximate the behaviour of loosely packed flocs of material. Then the aerodynamic diameter would be somewhat more dependent on fiber length and less dependent on fiber diameter than for the case of needle-like fibers.

Specification of cotton dust air cleaning equipment is complicated by having to deal with two distinct classes of aerosol particles; particles which are more or less isometric in shape, and fibers. In the first case there is a direct relationship between particle mass and aerodynamic diameter, in the second case there is little, if any relationship. For this reason, air cleaners can behave quite differently when assaulted with the same mass concentration and apparent size of particles and fibers.

2. Hazard of Cotton Particles

The same mass of a cotton aerosol which contains mostly fibers may not represent the same inhalation potential as a cotton dust aerosol which contains mostly particles. Thus it is necessary to look at both the fibrous and the non-fibrous parts individually. Fortunately, the heterogeneous nature of cotton dust permits a fairly simple classification of the dust into a fibrous and non-fibrous component.

The undesirable material in ginned cotton, as it is received at the textile mill, consists of fragments of cotton leaf and seeds and also soil and inorganic dust particles. These materials are removed from the cotton during the processing of the cotton and spinning of the yarn. The principal air contaminants which are produced are small leaf particles and plant fragments, inorganic dust from inorganic material carried on the cotton or cotton leaf as well as other possible contaminants such as insecticides, bacteria and fungi fragments. Finally, there are the short cotton fibers, known as "fly" in the cotton mill or "lint" to the layman.

It has long been recognized that the inhalation of cotton dust may result in both acute and chronic ailments. The acute disease, originally called "cotton mill" or "Monday" fever is a non-disabling, temporary allergic reaction which disappears after a day. Not all individuals respond to the effect of cotton dust. Recent work by Schilling (3) and others has shown that the allergic reaction known as "Monday" fever is actually the precursor of the more chronic form of byssinosis. The term byssinosis now takes all stages of response into account. Thus it is common to refer to various grades of the disease as shown in Table 1.

Table 1

VARIOUS GRADES OF BYSSINOSIS

<u>Grade</u>	<u>Description</u>
1/2	Monday Fever occasionally
1	Monday Fever always
2	Monday fever (or response) during the first part of every day
3	Permanent disablement

Although when one thinks of cotton dust one thinks of fibers, most investigators now feel that the causative agent for byssinosis is in the particulate plant material, rather than being associated with the fibrous cotton which may also be present in the air.

B. MEASUREMENT OF LINT AND DUST

1. Sampler Characteristics

Current interest in measuring dust levels in cotton mills has centered around assessment of the potential for byssinosis development within the mill. It has long been established that byssinosis could be prevented by reducing workers' exposure to airborne dust. In early studies the best correlation between the incidence of the disease and the dust levels was found when the dust level was characterized by the middle-sized particles of relatively high protein content (3). In more recent studies the combined levels of middle sized and fine dust appears to provide an even better correlation with byssinosis incidence. This could be due to some of the factors explained above, or to differences in sampling techniques, as well as to differences in diagnostic grading of the disease.

Although there is a strong finger of suspicion pointed at the bracht from the cotton plant stem as being the causative agent, the exact agent (or agents) which cause the disease have not been identified, and it is quite possible that the proportion of this agent in the dust may vary widely from one study to the next, depending on the location in the plant where the study was made, the grade of cotton being processed, and individual susceptibility. This could account for differences observed in various studies.

For all of the above reasons, until recently there has been little uniformity in methods used to measure dust levels in the mills and there have been very few attempts at determining size distributions of the dust particles which would be useful information for designing air cleaning equipment.

The sampler developed by Lumsden and Lynch (4) and the one which is currently the favorite in most American studies of byssinosis consists of a vertical conical chamber surmounted by a cylindrical chamber 6 inches

in diameter and 14 inches high. The sample is drawn upwards at a rate of 7.4 liters per minute through the conical section and then upward into the cylindrical portion where an average air velocity of 0.667 cm/sec is attained. In theory this sampler should fail to pass all particles having aerodynamic diameters greater than 14.8 microns while passing all smaller particles. In practice the cut is not so accurate, due to the impossibility of maintaining full plug flow within the cylindrical portion. Instead, a somewhat parabolic-shaped flow is developed, so that some annuli of the upward moving air have velocities greater than 0.667 cm/sec, while other annuli have velocities less than this. For example, considering the sampler to be divided into 5 concentric annuli having radii of 0.2, 0.4, 0.6, 0.8, and 1.0 times the cylinder radius, it is possible to estimate the fractions of different size particles which will be passed by the sampler (Table 2).

Table 2

<u>Annulus</u>	<u>Percent of flow</u>	<u>Aerodynamic diameter of max. size escaping</u>
0 -0.2	7.8	20.9
0.2-0.4	21.4	20.0
0.4-0.6	29.4	18.2
0.6-0.8	28.0	15.0
0.8-1.0	13.4	9.2

A second method of measurement of respirable dust used in the cotton industry is that described by Roach and Schilling (5). This method is used principally in England although it has also been used in the United States in studies by Bouhuys and his colleagues (6,7).

The apparatus is based upon the hexlet sampler described by Wright (8). Two samplers are used. In one unit air is drawn at a constant flow rate through a horizontal elutriator which permits only the fine dust to pass and be collected. This elutriator is designed so that 50% of the particles with an aerodynamic diameter of 5 microns are deposited and 50% pass through the unit. Particles larger than 7.1 microns do not pass through the unit. In the other unit the elutriator is removed and replaced by wire gauze with square holes, 2mm by 2mm. Dust collected on the wire gauze is considered to be "coarse" dust. Dust penetrating the gauze is considered to be medium and fine. Dust passing the sampler with the elutriator is considered to be "fine". Thus the amount of "medium" dust is obtained by the difference in weights or dust passing the two samplers.

A third method for sampling cotton dust is that used by Hammad and Corn (9). Their method is similar to that of Roach and Schilling except that for the coarse dust an open-faced millipore filter is used instead of wire mesh. They consider that this modification gives much more realistic results since with Roach and Schilling's method it is possible to lose a large part of the sample when it is wiped off the wire mesh.

Yet another cotton dust sampling method is that specified by OSHA using 37 mm membrane filters as personal samplers. The sampler is attached to the clothes of the workman with the face of the filter pointing down. In theory, at 1.5 lpm, unit density particles smaller than about 25 microns are collected. This type of sampling does in fact discriminate against some of the larger cotton fibers but not all of them. There is no published correlation of data from this type of sampler with any epidemiological investigations of byssinosis in cotton mills.

The variety of sampling methods has created a great deal of confusion as to the sizes of dust which are present or should be considered to be important. The data of Roach and Schilling have shown fairly good correlation of byssinosis with the medium sizes of dust, and somewhat poorer correlation with only the smallest size fraction. On the other hand, there was poor correlation with the large size fraction. This was the reason for the adoption of the design of Lumsden and Lynch by Kilburn and Merchant for their studies of North Carolina textile workers (10), since this sampler collected both the medium and fine dust portions while excluding the coarse portion.

2. Size Distribution of Cotton Dust

Cotton dust is composed of a variety of materials having both isometric and fibrous shapes. For this reason it is convenient to consider the particles and the fibers separately.

Cotton fibers can be considered to be either mature or immature. Mature fibers have lengths ranging from several millimeters to several centimeters, with the better grades of cotton having the longer fiber lengths. Immature fibers, on the other hand, can be quite small. Cotton fibers are principally cellulose, contrasted to the plant trash which can be much higher in proteinaceous material. Most investigators (e.g. Kilburn, et al. (13)) do not attribute any particular health hazard to cotton fibers. At the same time it appears that fibers are relatively easy to clean from the air by conventional means and air cleaning devices of the type now in current use are quite efficient in removing both mature and immature fibers. Since a large portion of airborne mass in a cotton mill could be attributed to fibers, simple air cleaners can be effective in removing a large part of this mass. If the purpose of the air cleaning is the prevention of byssinosis then removal of the fibers is meaningless. If anything, their absence from the workroom air could lead to a false sense of security since this would not insure the absence of respirable dust. On the other hand, large quantities of fibers in the air can interfere with the operation of air samplers or air cleaners designed for the removal of fine particles so that the fibers cannot be completely ignored. Thus oftentimes it is necessary to have a multistaged system where one portion of the system is designed to remove fibers and a later portion to remove particulates, or isometric particles.

An isometric particle is defined as one whose three major dimensions are approximately equal. Although for some of the leaf fragments making up the cotton dust this may not be strictly true, there has been no attempt to separate the dust into a particle and platelet fraction. Here the two will be considered together.

Lynch (12) studied typical airborne cotton dust and reported the following cotton dust size fractions:

Table 3

COTTON DUST SIZE FRACTIONS

Operation	Percent of Dust by Weight		
	Lint	Middle	Respirable
Opening, blending, picking	58	26	16
Carding	67	25	8
Spinning	60	33	7

Using a cascade impactor Lynch measured an aerodynamic mass median diameter for the dust (excluding lint) of 4.5 microns with a geometric standard deviation of 3.0. This is the average of four long-term samples.

Hammad and Corn (9) reported for their studies:

Table 4

COTTON DUST SIZE FRACTIONS

Operation	Percent of Dust by Weight		
	Lint	Middle	Respirable
Opening	66.2	22.5	11.3
Picking	50.0	21.4	28.6
Carding	66.6	16.7	16.7
Drawing & Roving	84.3	9.4	6.3
Spinning & Winding	88.8	5.6	5.6

The reduction of the respirable or fine dust percentage as the cotton moves through the processing operation reflects the cleaning of plant

trash from the cotton in the various manufacturing steps. The data from these two studies also indicates some of the problems associated with attempting to remove byssinosis producing dusts. The fiber fraction represents the largest fraction by weight of airborne material during any stage of manufacture, but this is not the fraction that is biologically significant. It was for this purpose, i.e., to ignore the lint fraction of the airborne material, that the Lynch and Lumsden sampler was developed. Data from their sampler should represent primarily the middle and respirable portions of the dust cloud, although the data are not directly comparable.

As reported by Merchant (14) samples collected by the vertical elutriator appear to be mainly vegetable in origin. The samples have a brown color and appear to consist of fine pieces of bract, leaf, and stem with relatively few fibers. Although the particles are irregular in size and shape, they appear to be remarkably uniform. Microscopic sizing reveals the following size distribution of the collected material.

Table 5

PROJECTED AREA DIAMETER OF COLLECTED COTTON DUST, MICRONS

	<u>0 - 1</u>	<u>1 - 2</u>	<u>2 - 3</u>	<u>3 - 7</u>	<u>7 - 15</u>	<u>>15</u>
Percent in size interval	45.8	23.6	17.2	7.4	3.9	2

In order to estimate the initial size distribution of the medium and smaller particles from these data, it is necessary to divide the percentages by the collection efficiencies of the vertical elutriator.

3. Dust Levels

Dust levels in various cotton mills will vary with the type of operation, location of the sampler and grade of cotton being processed, as well as with the type of dust suppression equipment used. Data of Hammad and Corn (9) for a typical cotton mill with local exhaust ventilation on the carding machines show that although total dust levels can range as high as 7 milligrams of material per cubic meter in the opening room, a more realistic overall total dust concentration lies in the range of one to two milligrams per cubic meter. Data by Roach and Schilling shows much the same levels as does that of Wood and Roach (11). Lynch's data (12) regarding total dust levels in three mills gives somewhat higher results. These are summarized in Table 6.

Table 6

Operation	Concentration, mg/M ³									
	Mill	Total Dust			Personal Sampler			Respirable Dust		
		A	B	C	A	B	C	A	B	C
Opening										
Picking	8.2	5.0	6.5	4.0	1.8	1.6	1.0	0.4	0.6	
Carding	3.2	9.5	2.3	1.5	4.3	3.2	0.3	0.4	0.3	
Drawing	-	3.0	-	-	2.1	-	-	0.3	-	
Spinning	7.4	0.9	3.7	0.9	0.5	0.6	0.3	0.1	0.1	
Winding	14.3	-	-	1.2	-	-	0.3	-	-	
Weaving	-	1.3	1.4	-	0.7	0.8	-	0.1	0.7	

Differences in data could be due to a number of causes. It is not clear whether these mills were equipped with local exhaust ventilation nor is the grade of cotton specified. Both of these factors could easily contribute to the differences noted.

An extensive set of data using the vertical elutriator of Lumsden and Lynch is that of Merchant, Kilburn and their associates (14). Data from six cotton mills, comprising of 670 samples, are summarized as follows:

Table 7
1971-1972

<u>Operation</u>	<u>Median level, mg/m³</u>
Opening and blending	1.5
Picking	1.6
Carding	1.7
Drawing	0.8
Roving	0.5
Spinning	0.3
Wind and twist	0.3
Weaving	1.0

The high value for the weaving area probably reflects the addition of starch or some other additive to the yarn prior to weaving.

Although the values reported here represent median values for several cotton mills, it would be incorrect to assume that they are necessarily typical of median levels which might be found in the cotton industry as a whole. As mentioned previously, such diverse factors as type of cotton being processed, type of hoods or dust control devices in use, equipment age, and equipment layout all can influence the dust concentrations observed in any area within a plant. In addition, in some instances it is possible to have zones of high and low concentration existing within the same room in a cotton mill so that the location of the sample will influence the reported result. Table 8 shows summarized results of dust

measurements made during this study in various mills with varying degrees of control processing varying grades of cotton. These results serve only to indicate the ranges of concentrations which may be expected for the different operations, with and without dust controls.

Table 8

RANGE OF TYPICAL LINT AND DUST CONCENTRATION, mg/m³

<u>Operation</u>	<u>Total</u>	<u>Dust*</u>
Picking, no control	-	0.6-1.6
Picking, control	0.4-0.7	0.3-0.4
Opening and picking, no control	1.5-9.1	0.2-1.9
Opening and picking, control	-	0.3-0.5
Carding, no control	5.2-21.2	0.3-5.4
Carding, control	0.5- 8.4	0.1-4.2

* As measured by the vertical elutriator

It appears that in some instances it may be possible to find low ambient concentrations (<0.5 mg/m³) near cotton processing operations where no dust control devices are in use, but this would be the exception rather than the rule.

It should be noted that with dust control the total lint and dust concentration measured using the high-volume sampler approaches the dust concentration measured using the vertical elutriator. This reflects the effectiveness of most any control method to remove the lint portion of the suspended matter. The relatively large range of results for vertical elutriator samples on systems where controls were in operation illustrates the variability of the problem; without specifying other factors such as cotton grade, etc., the data make little sense. However, as indicated elsewhere in this report, with properly designed hoods and adequate air flow into these hoods, quite low ambient dust levels can be attained.

4. Dust Concentrations in Return Air

If air is completely recirculated in a room receiving dust at one point and being cleaned at another, then with time an equilibrium dust concentration will become established in the room. This equilibrium concentration will depend directly on the amount of dust being produced in the room and inversely on the flow of recirculating air and the filter efficiency. It can easily be shown that for ideal conditions the room dust concentration will be equal to the discharge air concentration plus the ratio of dust production rate to the recirculating air flow rate. Thus with good dust capture (and hence a low dust production rate), the concentration of dust in the air which is returned to the workroom will eventually determine the concentration of dust in that space.

Dust concentrations in the return air were reported by Hammad and Corn (9) as 0.21 mg/M³ in the picking areas, 0.20 mg/M³ in the carding, drawing and roving areas and 0.13 mg/M³ in the spinning, spooling and winding areas. Although not explicitly stated, these data probably represent total dust concentration in the return air.

Similar measurements were made during this study at locations where various types of air cleaning equipment were in operation; measurements being made on the downstream side of the cleaners prior to the air going to the air conditioners. These results are summarized in Table 9.

Table 9

<u>Mill</u>	<u>Air Cleaning Equipment</u>	<u>Average Total Dust Concentration, mg/M³</u>
1	Rotary drum filter only	0.26
2	Single stage rotary drum filter	0.28
3	Single stage rotary drum filter and deep media (auto. filter)	0.16
4	Single stage rotary drum filter and AAF roll-up paper	0.14
5	Single stage rotary drum filter and deep polyester filters on V cells	0.10

Additional tests on a two-stage rotary drum filter demonstrated that discharge concentrations could be maintained at somewhere around 0.15 to 0.2 mg/M³. Although a high volume sampler was used on these tests, the samples penetrating the air cleaners represent particles of medium to fine sizes and thus could mostly be considered to be respirable.

These studies show that with proper dust collection and cleaning of the collected dust, it is possible with present technology to achieve dust levels of about 0.15 to 0.2 milligrams per cubic meter in cotton mills where complete recirculation of the interior air is required. Since there is always some leakage of air with the subsequent addition of clean make-up air, these concentrations could be perhaps 10% lower. However, as pointed out elsewhere in this report individual factors of each mill such as machine location and isolation (or lack of it) of dusty areas from non-dusty areas make achievement of this ideal goal in many cases quite difficult without extensive engineering studies of air flow patterns within the plant.

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II. The Solutions

A. Introduction

Opening, picking, carding, combing and drawing machines used to produce cotton textile yarn also produce cotton waste and dust in copious quantities. It is, in fact, a function of each of these machines to clean these undesirable contaminants out of the desirable fibre formations. A modern high-speed cotton card, for instance, producing 40 pounds of cotton sliver per hour, may produce 1.6 pounds of waste per hour. It is obvious, then that a production unit of 39 such cards (which is not uncommon) would produce a 500 pound bale of waste in every 8 hour working shift.

1. Exhaust Systems

Exhaust hoods on the machines capture the waste and dust, and exhaust systems under suction transport it away from the machines to a system of waste and dust separators. The function of these separators is to remove the waste and dust from the air transporting it so that the transporting air may either be returned to the workroom or be discharged to the air outside the factory. In general less efficient waste and dust separation would be required if the transporting air were discharged outside the factory than if it were to be returned to the workroom. However, air discharged outside the factory has to be replaced in the workroom by make-up air from outside the factory. This make-up air must be heated or cooled, humidified or dehumidified and, in some cases, cleaned before introduction to the workroom. It is therefore usually more economical to use the more efficient waste and dust separation equipment required for return of the transporting air to the workroom, than to discharge the transporting air outside the factory and then replace it with make-up air. This section addresses itself to the nature of the more efficient separation equipment required to accomplish this objective.

2. Workroom Ventilation

It should be noted at this point that even with 100% return of exhaust system air to the workroom, it is still necessary to ventilate the workroom itself by supplying some fresh outdoor air to the workroom and allowing some of the workroom air to vent to the outside. This can be accomplished by a workroom ventilating system separate and distinct from the machine exhaust system and its separators; or by venting some of the exhaust system air to the outside and replacing it with make-up air from the outside. It is usual design practice to assume that the workroom will be under a slight positive pressure and that there will be approximately 10% outward leakage from the workroom that will have to be made up with make-up air. The percentage of outside make-up air will vary with the season of year. Both the temperature and humidity of workroom air must be controlled and the use of make-up air is involved in both. Humidity control is more important than temperature control as far as the product is concerned. Temperature control is more important than humidity

control as far as the people in the workroom are concerned. As has already been noted, in some cases it may be desirable to clean the make-up air before introducing it to the workroom. This can be accomplished either by using conventional air cleaning equipment designed to clean make-up air from the outside; or by using the more efficient dust separating equipment incorporated in the exhaust system for this purpose. In the diagrams of exhaust systems that follow, vents to the outside, make-up air from the outside and separate cleaners for these two air streams are not included. However their exclusion is not intended to indicate that they may not be needed.

The textile industry for a long time has been using "lint" filters ahead of air washers to improve the life of the washers. These have employed both V-screens using 1/16" to # 50 mesh screens and thick non-woven polyester media. Where roll filters using paper media have been used ahead of air washers, they have frequently been preceded by V-screens of the type noted above. It has long been considered good practice to take advantage of such filters at all times and to pass return air through them even when the washers are by-passed for whatever reason such by-pass may be indicated.

3. Air Conditioning Systems

It must be emphasized that air conditioning is not a substitute for air cleaning. Air conditioning is mainly concerned with control of air temperature and humidity and can be accomplished by systems which accomplish little or no air cleaning. An air conditioning system usually uses an air washer as part of the means to accomplish temperature and humidity control. However these air washers are not designed as efficient air cleaners and should not be considered as such. The greater the dust and lint load allowed to enter an air washer the more maintenance it will require. Although dust is objectionable in an air washer, lint is worse because it can completely foul it up. For this reason an air washer in an air conditioning system is usually preceded by some form of pre-cleaner to prevent lint from entering it.

B. Primary, Secondary and Tertiary Separators

The several separators shown on Figures 1 - 7 represent the three stages of separation found in systems for cotton textile yarn producing machine exhaust ventilating systems. The primary waste separators and concentrators are the lint pre-separators which are the first stage of separation in such systems. The units labeled "Primary Waste Separator" in Figs. 1, 2, and 3 are condensers which separate waste but let most of the dust pass through. They have been in common usage in the U.S. textile industry for some years. They discharge visible and invisible dust in concentrations that sometimes exceed 150 milligrams per cubic meter of air. The units in Figs. 3-7 labeled "Primary Waste Concentrators" serve the same purpose except that they do not act as waste condensers. Instead they pneumatically feed a waste stream to a remote condenser labeled "Secondary Waste Separator".

The secondary dust separators of Figures 2 through 7 are the second stage of separation. The visible portion of the dust leaving the primary stage can be effectively controlled by separators with automatic cleaning devices or more simple ones which must be cleaned manually. Separators of both these categories have been proven by many years of operation on relevant textile machines. In most existing systems in textile mills such secondary separators are intended to control coarse dust but are not designed to prevent fine dust from entering the air washer and the workroom air. There are, however, types of separators capable of controlling both coarse and fine dust when used as secondary dust separators.

In general it is preferable to have all stages of pre-separation, concentration and separation, that are used in a system, operate in a continuous automatic mode rather than in a discontinuous or intermittent mode. In the latter two modes the system must be shut down periodically for dust or lint removal. Failure to observe such periodic shut downs can force the system to shut down at an unplanned time with a resultant unplanned shut down of plant production. With properly designed and maintained continuous automatic air cleaning systems such unplanned plant outages attributable to the air cleaning systems should not occur.

1. Systems Using Primary Separators

The simplest system is shown in Fig. 1 in which a primary waste separator is used to clean the exhausted air. There are several objections to this system. Assuming that the primary waste separator is a condenser, the air leaving it and entering the air washer is dust-laden. Although the air washer will remove some of this dust, air washers are not designed to be efficient dust separators. Therefore the conditioned air to the workroom will carry a high load of dust. Since the water in the air washer is recirculated, the more dust it retains, the less it can be recirculated.

Any failure of the waste separator to do an efficient job of waste separation will allow waste to enter the air washer, thereby forcing the air washer to become a secondary waste separator. Although an air washer can perform this function for a limited time, it is not designed for this purpose and will be soon forced out of operation by the incoming waste.

2. Systems Using Primary and Secondary Separators

An obvious improvement over the system shown in Fig. 1 is that of Fig. 2 which adds a secondary dust separator to remove dust before its entry into the air washer and the workroom air. The secondary dust separator also will protect the air washer and allow its uninterrupted operation. When the primary waste separator is operating properly, the secondary dust separator will collect only the dust which escapes the primary waste separator. However, when the primary waste separator malfunctions, the secondary dust separator will also have to collect the waste escaping the primary separator.

3. Systems Using Primary, Secondary and Tertiary Separators

If the type of collector used for the secondary dust separator in Fig. 2 is one which will separate only coarse dust, then a tertiary dust separator capable of separating fine dust must be added, as shown in Fig. 3. There is obvious redundancy in having two dust separators in series. If the secondary dust separator were eliminated, the tertiary separator could collect both coarse and fine dust. The arguments for using both separators in series are that the secondary dust separator will protect the tertiary dust separator from any malfunctions of the primary waste separator that will allow waste to enter the secondary dust separator. Also by removing the coarse dust, the secondary dust separator will lighten the load on the tertiary dust separator. However the overall pressure drop across the two separators in series, their initial cost and cost of operation will most likely be greater than the use of a single dust separator capable of removing fine dust and of coping with the occasional entrance of waste, i.e., of omitting the secondary dust separator and retaining only a tertiary separator of appropriate design.

4. Systems Using Primary Waste Concentrators

An alternative to the use of a condenser as the primary waste separator, is to use as a preseparator a primary waste concentrator (Fig. 4). This type of unit concentrates waste into one effluent air stream and dust into another. The waste stream goes to a condenser, similar to the primary waste separator of Figs. 1-3, but in this case used as a secondary waste separator. The dust stream goes to a secondary dust separator similar to the secondary dust separators of Figs. 1-3.

Since this type of unit separates dust from waste, it can be considered a separator or preseparator which concentrates and could be given any one of several possible names other than the one used here - "Primary Waste Concentrator".

In the system, shown in Figure 4 as in that of Figure 2, if the secondary dust separator is capable of removing only coarse dust, fine dust will pass through and will enter the air washer and the workroom. Some dust will accompany the waste going from the primary waste concentrator to the secondary waste separator. Some of this dust will go through the secondary outlet air to the inlet of the secondary dust separator, this dust can be separated to the extent that the secondary dust separator is capable of so doing.

The system shown in Fig. 5 adds a tertiary dust separator to the system shown in Fig. 4. By virtue of the presence of the tertiary dust separator it is possible to vent the secondary waste separator outlet air to either the same location as in Fig. 4 (alternate A on Fig. 5) or to the inlet of the tertiary separator (alternate B on Fig. 5), in either case with assurance that its dust load will not reach the air washer and the workroom air.

5. Systems Using Rotary Drum Filters

A variant of the system shown in Fig. 4 which employs a vacuum cleaned rotary drum filter as the secondary dust separator is shown in Fig. 6. The rotary drum filter acts as a secondary separator with respect to any waste that might escape the concentrator thereby protecting the air washer from waste.

An obvious means to prevent an excessive dust load from reaching the workroom air is to back up the rotary drum filter with a tertiary separator. Fig. 7 shows a system which uses a tertiary filter. By virtue of three stages of protection from waste, the concentrator and two dust separators, the air washer is fully protected against fouling by waste. It should, of course, be recognized that equipment failure can occur as a chain reaction starting first with separator failure, which in turn can induce filter failure, which in turn can induce fan failure, in which case everything stops.

6. Systems Using Waste Separators as Dust Separators

In all the systems discussed in Figs. 1-7, it has been assumed that the waste separator (primary in Figs. 1-3 and secondary in Figs. 4-7) is a condenser which forms a mat of waste fibres on a rotating drum and which doffs the mat continuously into a receptacle beneath the condenser. The mat on the drum acts as a filter for some of the dust particles in the entering air stream but presumably most of the dust passes through the mat and leaves with the outlet air stream. Because of this there is some unavoidable contamination of the waste by the dust it collects. This contamination will be greater in the systems of Figs. 1, 2 and 3 which do not use a preseparator as a concentrator and minimal in the systems of Figs. 4 and 5 which do use the preseparator as a concentrator. When the system of Fig. 6 is used in the mode marked A and a, the outlet air from the secondary waste separator is returned by alternate path A to the inlet of the rotary drum filter from which the dust is returned to the inlet of the secondary waste separator by alternate path a where some of this dust will be collected on the waste mat. If the effect of collection on the rotary drum filter is to cause dust particles to agglomerate and increase in size, the agglomerated dust will have a better chance to be collected on the waste mat in the secondary waste separator than if it were not so agglomerated. This is probably usually the case. However if the dust entering the secondary waste separator from the rotary drum filter is not well agglomerated it will not be well collected on the mat and will recirculate to the rotary drum filter inlet, thereby increasing the inlet dust load to the rotary drum filter. Assuming a constant dust collection efficiency for the rotary drum filter, an increase in inlet dust loading will result in an increase in dust leaving the filter and entering the air washer and the workroom air. Since directing the dust-laden air from the secondary waste separator to the air washer inlet is an untenable solution, the only alternate is to vent the secondary waste separator outlet and its dust load outdoors as in the alternate path marked B. This solution is viable only if the dust load is within limits permitted by air pollution control regulations. Where the dust load is beyond such

limits, and path B is preferred to path A, it will be necessary to clean the air before discharge to the outdoors by some method such as the use of a tertiary dust separator. Venting outdoors will contaminate the air around the factory that serves as its make-up air and will therefore be less effective in preventing byssinosis than will a system that effectively separates and disposes of its byssinosis producing dust. It should be noted that to the extent that the waste from the secondary waste separator is maximally contaminated by dust, subsequent reuse of the waste may release byssinosis producing dust at its point of reuse.

The above noted problems of recirculating dust load and contaminated waste can be avoided by the use of an efficient dust collector in the rotary drum filter vacuum stripper line. If this were done the outlet air from the dust collector could go either to the inlet of the secondary waste separator or the secondary dust separator.

These are shown as alternate paths b and c respectively, in dotted lines on Fig. 6. It could, of course, also go to the air washer inlet and outdoors. These options are not shown on Fig. 6.

Several additional alternatives exist when a tertiary dust separator is added to the system of Fig. 6 to create the system shown in Fig. 7. It is now also possible in theory to discharge the outlet air from the secondary waste separator to the inlet to the tertiary separator. However, practical experience indicates that path B on Fig. 7 is not a viable alternative because greater overall filter efficiency is always achieved through path A.

The problem of waste contaminated with potentially byssinosis producing dust remains to the extent that the secondary waste separator is efficient as a dust separator. If the tertiary dust separator is of the vacuum cleaned rotary drum type, the problems of recirculating dust load also remains, as do the solutions offered in Fig. 6 - venting to the outdoors (alternate path B on Fig. 6) or the use of an efficient dust collector on the rotary drum filter stripper fan vacuum cleaner line (alternate paths b and c).

C. Dust Separators Capable of Collecting Fine Dust

The principal thrust of this report is on tertiary dust separators capable of assuring that the air returned to the workroom has an acceptable level of fine (respirable) dust, or as noted above, of secondary separators having the same capability.

Dry dust separators fall into four general categories: those which depend upon the weight of the dust particle for its removal; those which effect removal by the application of an electrical force on the particle; those which retain the particle on or in a porous structure through which the carrier air flows; and those depending upon a liquid to retain the particle. Those depending upon particle weight are called settling chambers if only gravity acts on the particle. If a force of several "g's" are applied to the particle by causing it to move in a circular

path, the collecting devices are called cyclones or mechanical collectors. Those depending upon electrical force are called electrical precipitators. Those depending upon particle retention by a porous structure are called filters. Those depending upon a liquid are called wet separators.

1. Wet Separators

Before proceeding to a discussion of the separator types available there needs to be note taken of the exclusion of wet separators from the discussion. There are three reasons for such exclusion. The first is that it is assumed that an air washer is a part of each system and that the function of the air washer is to control workroom air humidity. The use of a wet type separator preceding the air washer would make humidity control by the air washer more difficult. The second reason is that wet waste is more difficult to handle and to reuse than dry waste. The third reason is that a wet dust separator is likely to become inoperable if significant amounts of waste enter with the dust, because of inefficiency or malfunction of the separating or concentrating equipment preceding the dust separator.

2. Settling Chambers, Cyclones and Mechanical Collectors

The smallest particle that can be collected at 95% efficiency by a simple settling chamber is 40μ ; by a mechanical or a commercial size cyclone is 5μ . Since the mass median diameter of cotton dust (excluding lint) is 4.5μ , it is apparent that the types of dry collector that depend upon particle weight for collection are not applicable to dust as fine as cotton dust.

3. Electrical Precipitators

Since electrical precipitators are capable of collecting particles as small as 0.1μ at efficiencies of over 95%, they should be capable of collecting cotton dust provided that the resistivity of the dust at room temperature falls within the range that permits collection, i.e. between 10^4 and $2-5 \times 10^{10}$ ohm - cm. Published tabulations of dust resistivity fail to list the resistivity of cotton dust but generally indicate that resistivity decreases with increasing moisture content of dust. Since byssinosis producing material is believed to be of natural origin and since materials of natural origin generally contain moisture, it is reasonable to believe that the cotton dust of concern would be within collectable resistivity range.

There are two main types of electrical precipitators: the single stage industrial type in which the same set of electrodes supply the electrical charge to the particles and the electrical force to cause the charged particles to precipitate on the collecting electrode; and the two stage air conditioning type in which one set of electrodes supplies the electrical charge to the particles and a second set supplies the electrostatic force that precipitates the charged particles. The single stage type generates ozone in the air passing through it and because of frequent sparkover between electrodes will ignite combustible material precipitated

on its electrodes. It also has the potential to cause an explosion should the dust mixture in the precipitator be both combustible and in the explosive range. For these reasons the single stage precipitator would not be applicable to the collection of cotton dust in a system which introduces the cleansed air back into the workroom as ventilating air. The two stage precipitator was developed to overcome some of these difficulties. It was designed primarily to remove the concentrations and kinds of dust found in the outdoor air from air entering air conditioning systems.

a. Two-Stage Electrical Precipitators

The two-stage precipitator resulted from the work of Penny (1) in the 1930's. In it, particle charging (Figure 8) is accomplished in an ionizer stage by alternate 5 to 10 mil tungsten wires, operated at positive D.C. polarity at relatively low voltage (ca. 13000 volts), and large diameter grounded metal rods. In some applications, two stages of ionizer banks, each of this design, have been required in series. Ionizer current flow is of the order of 4 to 10 milliamperes. The second, or collector, stage consists of light aluminum plates spaced $\frac{1}{4}$ inch apart in parallel. Alternate plates are at high potential (ca. 6000 volts) and at ground potential. Current flow is very small, the overall power requirement for both ionizing and collecting are from 15 to 40 watts per 1000 cfm. Precipitators are designed to operate under streamline flow conditions. Because of manufacturing irregularities, flow changes from streamline to turbulent considerably below 600 fpm. This sets the upper limit of design at about 450 fpm. In their usual application of removing atmospheric dust, tobacco smoke, and pollen from air conditioning systems, the velocity through the precipitator is from 300 to 450 fpm. At these velocities, there can be some reentrainment from the plates. If the plates are automatically washed or oiled, water or oil droplets may be also entrained. Under these conditions an aftercleaner to collect entrained material may be necessary. Some industrial collectors are intended to act as agglomeraters in which 100% reentrainment of the agglomerates is intended. In this type of operation an aftercleaner is mandatory.

For most industrial process applications, velocity is lowered to from 50 to 300 fpm. (Figure 9). If there is non-uniform air distribution across the precipitator, the extreme high and low velocities can be as high as 300 fpm on one side of the collector and as low as 100 fpm on the other. While the latter might collect at high efficiency, the former might not only be operating at relatively low efficiency but also be treating a higher than average proportion of total precipitator flow. Therefore not only must average velocity be kept within design limits but so must deviation from average velocity within the precipitator. This can be accomplished by the use of perforated baffle plates, before or after the precipitator; by turning vanes; and by a combination of both methods.

- (1) Penny, G.W. 1937. A New Electrostatic Precipitator.
Elec. Eng. 56: 159-63 (Jan.)

With the close plate spacing required to achieve precipitation at voltages lower than can cause ozone or oxides of nitrogen formation, or spark-over, a heavy dust build-up on the plates can cause collected material to bridge the gap between the plates and to short out adjacent plates. This is not a tolerable operating condition and must be avoided by the use of adequate precleaners preceding the precipitators to remove lint and coarse dust.

This is not a problem when handling atmospheric dust because of the low dust concentration involved. The usual methods for cleaning two stage precipitators are to take them out of service after several weeks operation and wash the plates down with water or oil either in place or after removal from the unit. There are collector designs which automatically wash plates fixed in place, or which automatically move plates into an oil bath for both plate cleaning and re-oiling (Figure 10).

Among the more successful industrial applications of this collector type are those in which the material collected is either an oil mist or combination of an oil mist and a fume or smoke. If there is sufficient oil present, it will drip from the plates and will carry collected particulate matter along with it, thereby preventing build-up on the plates. Under these conditions efficiencies of removal of over 99% by weight can be achieved.

The process gases that have been commercially cleaned by two stage precipitators include those from high-speed metal machining and rolling operation, meat smokehouses, asphalt saturators and coaters, cookers, curing ovens, etc. There has been limited application to the textile industry.

4. Filters

In view of the limited utility of other dust collector types to the problem at hand, it is indeed fortunate that filters, as a class, have all the characteristics required and are generally applicable to the removal of cotton dust from air prior to the use of that air in the building ventilation system for cotton mills. Therefore an extensive discussion of filters will be given.

Filters are most commonly a woven, knitted or felted fabric, but can include pierced, woven or sintered metal, and beds of a large variety of substances, such as vegetable, plastic or glass fibers, slag wool, metal turnings, coke, rock, sand, etc. A number of these materials and configurations are used for high temperature or corrosive applications and can be ruled-out as being unnecessarily costly and cumbersome for an ambient temperature non-corrosive application such as the filtration of building ventilation air. Those which are applicable are the woven, knitted or felted fabrics and the beds of vegetable, plastic or glass fibres. For purpose of further description, filters may also be classified with respect to cleaning cycle.

a. Discontinuously Cleaned Filters

On the one extreme are the throwaway filters which, when they become loaded with dust and lint, are thrown away and replaced with new filters. Filters of this type are generally supplied in a frame, usually 20 inches square and from 1 to 4 inches thick (Figure 11).

Next are the filters, also supplied in a replaceable frame of generally 20 inches square, in which after the unit is taken out of service the dust laden media is cleaned by vacuum cleaning or back washing, either in place or after removal of the frame from the filter structure, with subsequent replacement of the cleaned filter. (Figure 12).

Next are the filters, similarly supplied in a replaceable frame of generally 20 inches square, in which the dust laden media is thrown away, but the frame is retained and refitted with new media before replacement (Figure 13).

The prime characteristic of all these filters is that the pressure drop across the filter builds up from a low value at the time of replacement as a new, cleaned or refilled filter to a high value just before throw-away, cleaning or refilling becomes necessary because of the high pressure drop. There is a consequent decrease in air flow, which depending upon the fan characteristic, may be minimal or quite large. The second characteristic is that the system must be shut down for filter changing, cleaning or refitting. Although continuous operation could be obtained by having two parallel systems, one of which could continue operation while the other is shut down for filter change, cleaning or refitting, this is not common practice because of excessive cost of such dual systems. A third characteristic is that collection efficiency is lowest immediately after changing, cleaning or refitting and improves as a dust and lint mat builds up on the filter surface to improve filter efficiency. However if the filters are not changed, cleaned or refitted soon enough the increased pressure drop across the filter will promote bypassing of air around the filter through any leaks around the filter, in the frame or gasket, with a consequent loss of collection efficiency.

b. Intermittently Cleaned Filters

In this category of filter, the filter remains in place and is intermittently automatically cleaned in place. In this respect it differs from the panel filter frame that is manually, rather than automatically cleaned. Also, although the filter media in this class of filter will need replacement from time to time, such replacement is required because of eventual physical damage to the media caused by the means used for its intermittent in-place cleaning rather than because of increase in pressure drop across the filter. When a filter of this type increases in pressure drop, the in-place cleaning mechanism lowers the pressure drop to a lower as-cleaned pressure drop. Therefore the pressure drop of such filters varies between the lower as-cleaned value (which is higher than that for fresh filter media such as would be found in a replaced or refitted panel filter) and the higher before-cleaning value (Figure 14). It will be noted that the manually cleaned panel filter follows this same characteristic.

It depends upon the means of intermittent filter cleaning employed as to whether or not the filter must be taken out of service during cleaning. Simpler units must be taken out of service while the media is being cleaned. In more sophisticated systems, the units are sectionalized so that part of them remain in service while others are out of service for cleaning. Although such units are cleaned intermittently they provide service continuously. Since the pressure drop across the entire collector varies with time as one section is taken out of service, then put back in line and this cycle is repeated, there is a resulting variation in air flow through the system which depends upon the fan characteristic.

c. Continuously Cleaned Filters

In a continuously cleaned filter, dust is removed from the filter at a relatively constant rate, pressure drop across the filter remains relatively constant and air flow remains relatively constant. Continuous cleaning is achieved by either continuous removal of dust from the filter media at a uniform rate, or by continuous introduction of clean media and withdrawal of dirty media at a uniform rate. In the former the media must be replaced from time to time because of eventual physical damage to the media caused by means used for its continuous cleaning. In the latter the media is replaced continuously as the means for allowing the filter to operate at relatively constant pressure drop and flow rate.

d. Bag Filters

(1) Collection Inside the bag

As compared with fibrous mats, cloth and paper have the special property that they can be sewn or glued into bags of various shapes. Glued paper bags are commonly used in household vacuum cleaners, but rarely used in large scale air filtration. Cloth bags are the most frequently used form of filter in industrial exhaust ventilation systems. There are two principal configurations of bag filters in such systems. In the one, the dust is collected on the inside of the bag similar to the manner that dust collects inside the paper bag in a household vacuum cleaner.

(a) Shaking for dust and lint release

In the most common industrial practice a large number of such cylindrical closed-end bags are used with their axes vertical in a bag house with their ends open on the bottom (Figure 15). The air flow in each bag is up through the open end on the bottom, through the cloth cylinder and out, leaving its suspended dust and lint inside the bag. The bags are shaken to dislodge their contents which then fall by gravity into a hopper below. This system works well with dust. However, with small diameter bags usually employed, it is less effective with lint which can have a tendency to pack within a small diameter bag and not be cleanly released from the bag into the hopper by the shaking provided. For this reason this configuration using small diameter bags is not recommended for situations where lint can enter the collector should there be any malfunction of the lint removal equipment.

(b) Reverse Jet for dust and lint release

There is however, one design of collectors using large diameter cylindrical bags with collection on the inside which may be practicable for the collection of waste and dust. This is the reverse-jet filter (Figure 16) which uses bags usually made of a thick wool felt and blows the collected dust off the inside bag surface by a jet of high-pressure air through the felt. There is no textile industry experience to prove that lint can also be blown off the felt and that it will freely fall once it is blown off. It is quite likely that lint blown loose near the blow-ring may rapidly become reattached to the inside of the bag at another location, with the possible result of lint packing the entire bag.

(c) Bag Collapse for dust and lint release

Another method for releasing dust from the inside of a bag open at the bottom is to allow the bag to collapse by stopping air flow through it so that it is no longer ballooned out. This action allows the cloth to wrinkle and will break the dust-cake on the inside of the bag allowing it to fall into the hopper by gravity. However, it will have no loosening effect upon any lint collected in the bag. In fact, it would seem less likely for a mat of lint to fall through a collapsed bag than through one that was kept open.

(2) Collection Outside the bag

In the other bag configuration, either a pre-sewn bag is slipped over a wire mesh frame as a stocking would be slipped over a leg, or cloth is wrapped around a wire mesh form and the cloth ends attached to each other to complete a cylinder around the form. Air flow is from the outside of the bag and through the bag, which is prevented from collapsing by the wire mesh frame. The dust and lint originally suspended in the air are left on the outside of the bag from which location it must be removed. The wire mesh frame is usually cylindrical in which case the bag is in the form of a cylindrical stocking. However, in some designs the bag and its supporting frame are shaped like a pillowcase and a pillow respectively.

(a) Pre-sewn Stocking or Pillowcase (Panel or Envelope) Filters

As a class these filters employ a number of cloth bags in parallel. They differ one from the other in the means used for dislodging the dust and lint from the outside of the cloth to cause it to fall by gravity into the hopper below.

(1) Shaking for dust and lint release

By providing a shaking motion to the wire frames supporting the bag (Figure 17) the shaking motion can be transmitted to the bag. In commercial designs of this type collector, the channels between bags are sufficiently narrow as to make the packing of lint between the rows of bags likely and to make problematical the satisfactory release of such lint as would accumulate should there be a malfunction of the waste separating equipment. It would, of course, be feasible to build collectors of this type with sufficient space between rows of bags as to make lint packing less likely.

(2) Pulse-jet for dust and lint release

In pulse-jet cleaning of a cylindrical bag supported on a wire mesh form, a jet of compressed air is injected axially into the bag from a nozzle through a venturi at the top of the bag (Figure 18). As the jet travels the length of the bag its pressure causes the bag to bulge thereby cracking loose the dust caked on the outside of the bag, allowing it to fall into the hopper below. There is also an outward flow of the jet air through the cloth that aids in blowing the dust and lint off the outer cloth surface. If there is sufficient space between bags to prevent lint packing should there be a malfunction of the waste removal equipment and to allow collected lint to fall freely without bridging between bags, this type of design should be effective for use as removal equipment in most of the separators shown in Figures 1 through 7.

(b) Wrap-around (Drum) Filters

In one design of this type of filter, the cloth is wrapped around a cylindrical rotating drum wire mesh form. Air flow is from the outside of the cloth through the cloth to the inside of the drum. The dust and lint deposited on the outside of the cloth is cleaned by the rotation of the drum and its cloth wrapper past vacuum strippers (Figure 19). The vacuum stripper discharges its dust and lint to a dust collector.

One manufacturer's guidelines for this type of filter are:

1. The pressure drop across the filter must not exceed 3.0" w.g.
2. The dust must be dry. That is, it must be free of moisture, oil, and other liquids which would plug the media.
3. Face velocities should be in the 200 fpm to 250 fpm range.
4. Loadings should be in the 1.0 lbs./hr. to 4.0 lbs./hr. range. This is about 4 to 16 grains per 1,000 cfm.
5. Maximum temperature on applications is usually 100°F. The maximum allowable temperature is 140°F.
6. The nozzle arrangement is designed to handle fairly uniform layers of dust. Lumps and clumps of material will choke the nozzle and cause filter malfunctions and damage.

It is also possible to construct a drum filter with the cloth on the inside of the rotating drum wire mesh form and with air flow from the inside of the cloth through the cloth to the outside of the drum. Here the dust and lint deposited on the inside of the cloth is likewise cleaned by rotation past a stripper. In this design the cloth and stripper are inside the drum and therefore should be more difficult to work on and maintain. The vacuum stripper air should be released in such a manner as not to reintroduce any of the stripped dust to the workroom. This means that its exhaust must be either to the outdoors at a dust concentration that meets local air pollution control limits, or if it is returned to the workroom, it must be filtered through media at least as efficient as that used for the drum filter itself.

The drum filter should have no difficulty in handling the lint that might escape the waste separating system should it malfunction. However, the dust collector on the vacuum stripper line might have difficulty in handling a high lint load unless it is designed with this in mind.

A dust collector with the capability of handling a high lint load in this situation must be engineered specifically for this more difficult task, and will, as a result, be more costly than one of more conventional design. If the dust collector system on the vacuum stripper line is adequate, a drum filter should be capable of use for any of the separators shown in Figures 1 through 7.

e. Paper Filters

Several of the filters discussed under the heading of "Bag Filters", actually utilize non-woven fabrics. Specifically, the reverse jet filter preferably uses wool felt and the drum filter uses a range of filter cloths including a thick non-woven polyester medium. Thus the distinction between cloth and paper filters is not sharp. In any of the paper filters to be discussed in this section, a variety of non-woven fabrics can equally well be used. There are two major types of paper filters—roll filters and frame filters.

(1) Roll Filters

Roll filters use a roll of filter media the width of the filtration area and many times its length. They feed fresh media to the active filtration area as needed. They generally unroll fresh media from a roll at the top and roll up dirty media at a take up roll at the bottom. (Figure 20). The media unrolls onto a travelling wire screen to back up the media and help prevent its rupture. Despite this feature, tears and breaks do occur, which allow the passage of dust and lint through the filter. The rate of unrolling can either be intermittent, controlled by pressure drop through the filter to assure utilizing the maximum dust retentive capacity of the medium, or it can be at a constant continuous rate. If a filter of this type were to be flooded with lint due to a malfunction of the waste separating equipment it would most likely create problems, particularly in the take-up roll. A major problem with this type of filter is the necessity to keep supplying it with fresh rolls of filter medium. This is both costly and a maintenance problem.

When operated under pressure drop control the pressure drop will vary from a low value when clean medium is first exposed, to a higher pressure drop when it becomes dirty enough to roll up. Air flow will vary depending upon fan characteristic. When the filter medium is unrolled at a constant rate, both pressure drop and air flow should remain constant.

(2) Frame Filters

In order to increase the area through which filtration can take place, the media in frame filters is usually pleated (Figure 13). The area of media per frame increases with the number and depth of pleats. Where there is the possibility that the malfunction of a preceding waste separator or concentrator may allow large quantities of waste to reach the filter, such waste may pack deep narrow pleats rapidly decreasing the effective filtering area.

A frame filter is only as good as the tightness of the seal between the media and the frame. The maximum of tightness is found in filters where the media is glued to the frame. This is an expensive construction and requires the disposal of the frame with the media when the media must be replaced. It is therefore used mainly for extremely high efficiency/high pressure drop (absolute) filters. It does not make sense to use high efficiency/high pressure drop media in potentially leaky frames. Since all frames that must be periodically refitted with media by unskilled maintenance personnel are potentially leaky, this limits the kinds of media to be used to relatively low efficiency/low pressure drop media.

Leakage in frame filters is not confined to the seal between the media and its frame. There is also the possibility of leakage between the frame and its supporting structure, in the supporting structure itself and in its seal with the duct in which it is housed. Just as media is pleated to maximize surface area in a frame, frame supporting structures are frequently constructed in a pleated (V-shaped) pattern in ducts to maximize the total filter surface presented per unit of duct cross-sectional area. The more complex the supporting structure the more the opportunities for leaks to develop. Even though an individual filter frame may fit quite tightly into an individual support element at the time of their manufacture, the actual fit may be much poorer after all the bolts have been tightened to complete field assembly of a multiplicity of such frame supports. Similarly, the stresses applied to the frames to make them conform to their supports can adversely effect the integrity of the seal between the frame and its media. Finally, it is not uncommon that in the course of refitting a bunch of filter frames with new media and replacing them in their supporting structure, accidental holes and tears in the media develop and go either undetected or unrepaired.

Although, as has been noted, an excessive intrusion of waste can adversely effect the operation of frame filters, a small amount of lint should improve their performance by packing into seal leaks, holes and tears in the media thereby decreasing leakage and improving performance. It might even be a desirable practice to introduce a calibrated quantity of lint at start-up after filter replacement or refitting with new media for this purpose. This dosage might also be repeated after dust build-up on the media increases pressure-drop, both to increase the tightness of seals and also to increase the porosity of the dust cake on the media. This should have the effect of increasing the pressure drop across the frame seal and limiting the rise of pressure drop across the media.

It should be apparent from this discussion that it is not enough to know the efficiency of the media against cotton dust. It is more important to know the efficiency of the overall installation over a period of time i.e. the resultant of the efficiency of the media, the adequacy of its supporting structure and the history of the changes in both with time of use. This means that, although test data on a filter medium can allow us to reject that medium as unacceptable, only tests of a medium over a period of time in a complete system can allow us to consider it acceptable.

(a) Absolute Filters

Absolute filters are frame filters using high efficiency/high pressure drop pleated media glued to the frame, used with frames tightly sealed to each other to assure minimal structural support leakage. This is an expensive construction designed for use in removing radioactive particulate emissions from nuclear installations and for cleaning air entering "clean rooms". It does not seem reasonable to use such an expensive installation for cleaning air for return to a cotton mill where the extraneous sources of dust are so high.

f. Mat (In-depth) Filters

This is the class of filters that, instead of filtering through a single thickness of media as in the case of the bag or paper filters previously described, filters through a relatively deep bed of glass, vegetable, plastic or metal fibres, wires, ribbon or strands.

(1) Throwaway Filters

The most common example of this class of filter is the type used on domestic air conditioning and hot air heating installations. They are low efficiency/low pressure drop non-cleanable filters. The media and frames are almost always used flat rather than pleated or V-shaped. If a mat of lint fibres were to form on the filter it would not be expected to be more efficient than an equivalent mat of fibres on a condenser used as a waste separator. Therefore this class of filters does not seem to offer any filtration advantages in backing up condensers used as waste separators.

(2) Cleanable Filters

The principal difference between cleanable and throwaway filters is the construction of the frame, the means of packing retention and the depth of the packing. The throwaway generally uses a frame and a means of packing retention that will not maintain its integrity during even one vigorous filter cleaning cycle much less during a number of such cycles. The cleanable filter (Figure 12), on the other hand, is designed to maintain the integrity of both packing and frame through a multiplicity of cleaning cycles. This, of course, makes them more expensive. They therefore usually have a deeper filter bed than throwaways and have both higher efficiency and higher pressure drop. Their tolerance for high lint loading will vary with the type of packing. For many types of packing it will be more difficult to clean a lint-laden filter than a dust-laden one to a fully-cleaned state. Filters of this type therefore have questionable utility as tertiary separators.

(3) Automatic Viscous Filters

The automatic viscous filter is in effect a deep bed cleanable filter made of a number of layers overlapping thinner bed cleanable filter frames disposed as an endless belt in the manner shown in Figure 21.

Fig. 1. System Using Primary Separator

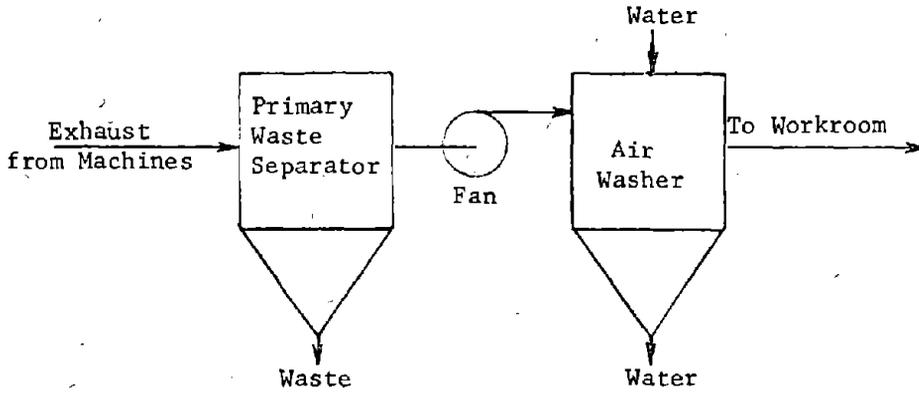


Fig. 2. System Using Primary and Secondary Separators

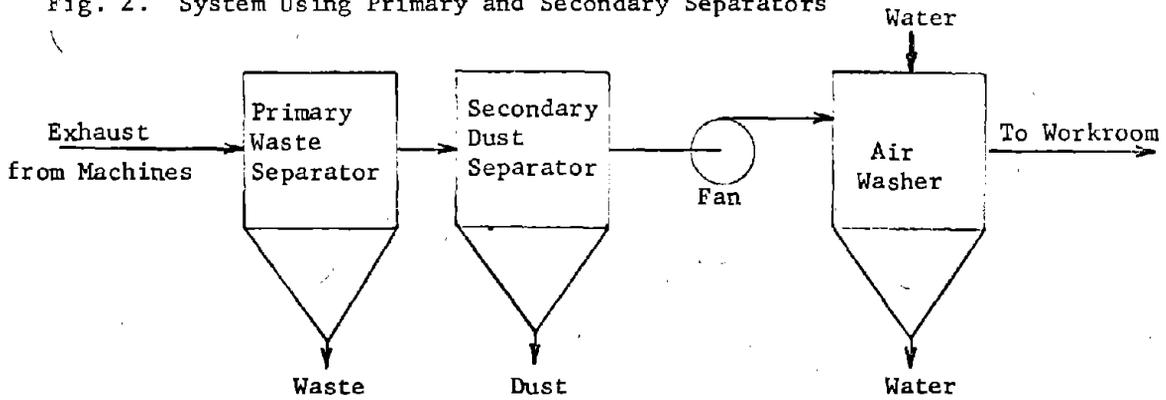


Fig. 3. System Using Primary, Secondary and Tertiary Separators

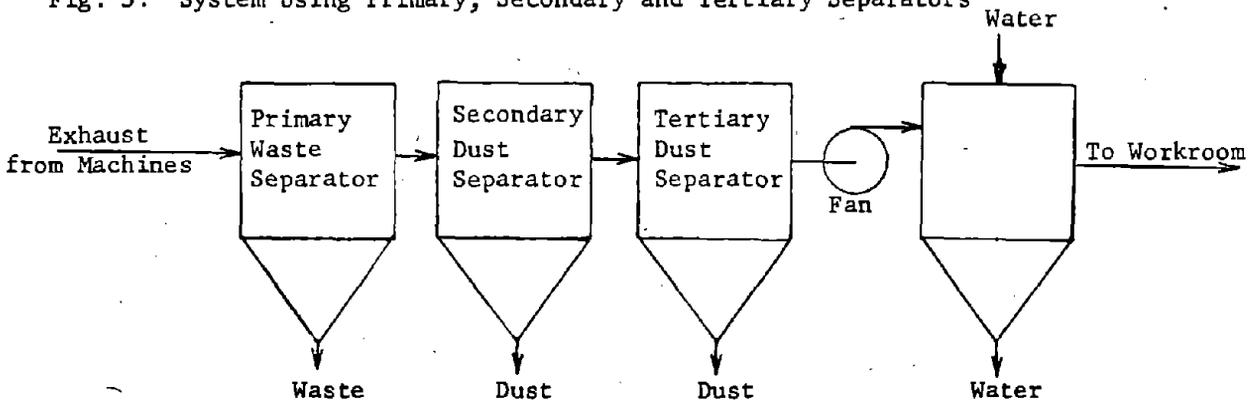


Fig. 4. System Using Primary Waste Concentrator and Secondary Separators

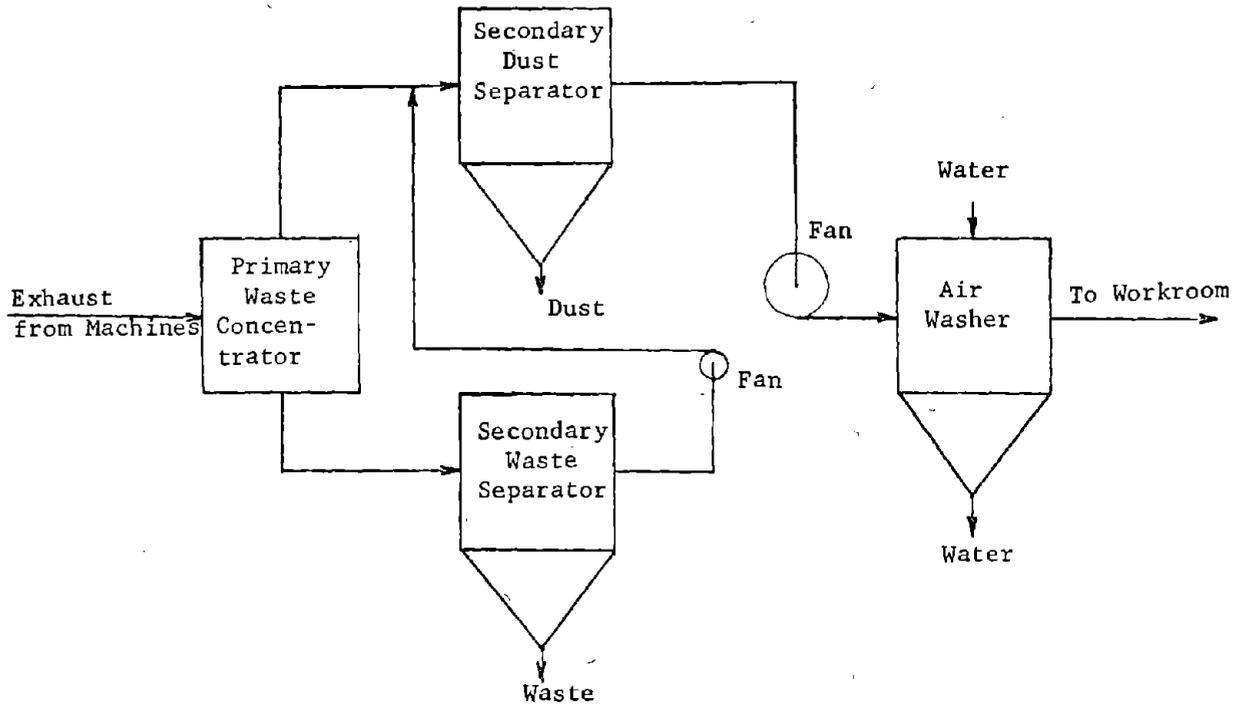
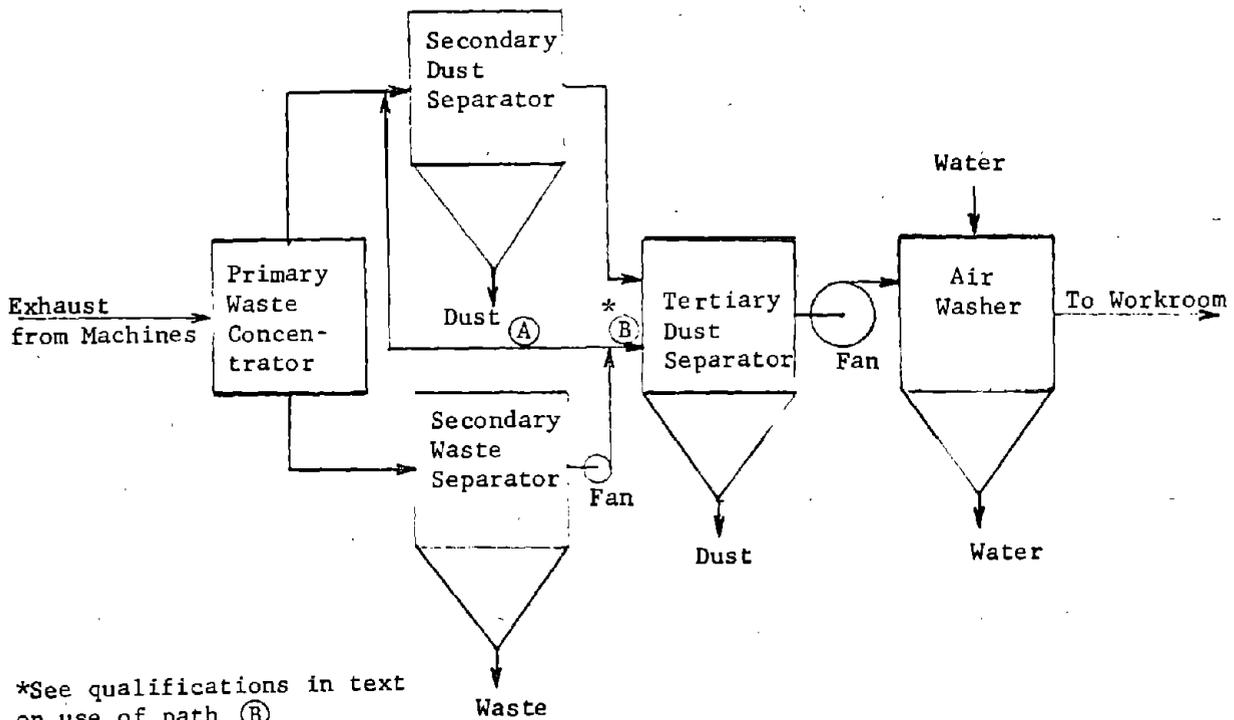


Fig. 5. System Using Primary Waste Concentrator and Both Secondary and Tertiary Separators



*See qualifications in text on use of path (B)

(A) and (B) Alternate Paths

Fig. 6. System Using Rotary Drum Filter as Secondary Dust Separator

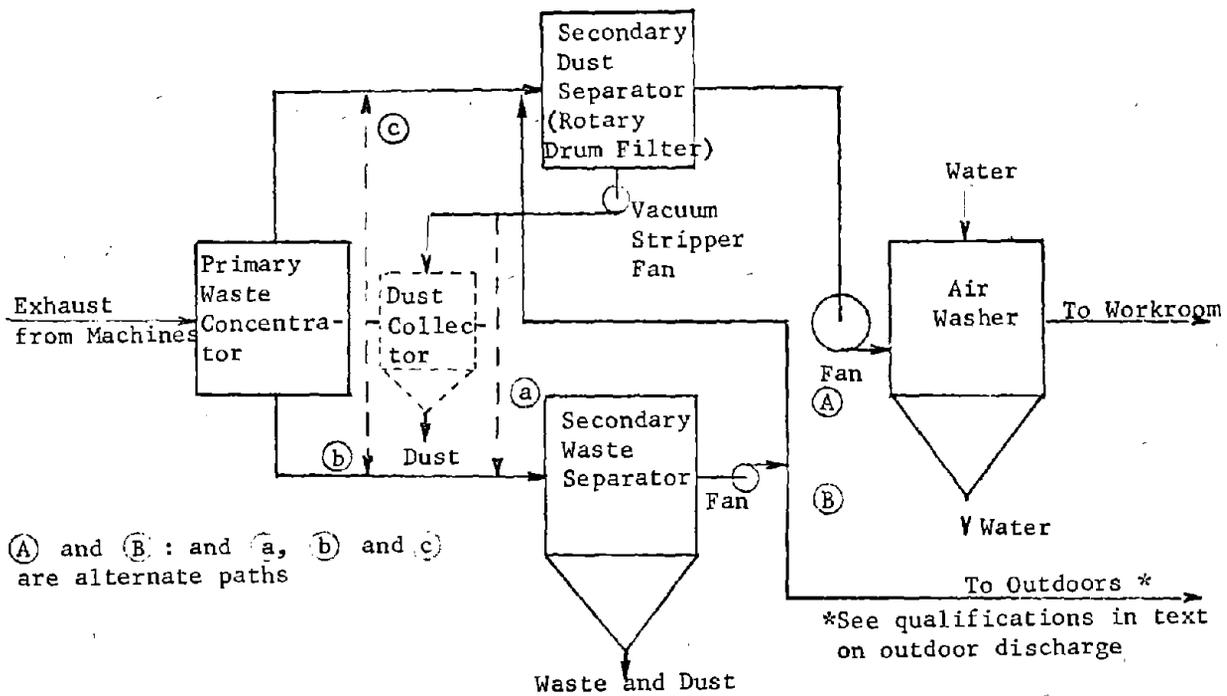
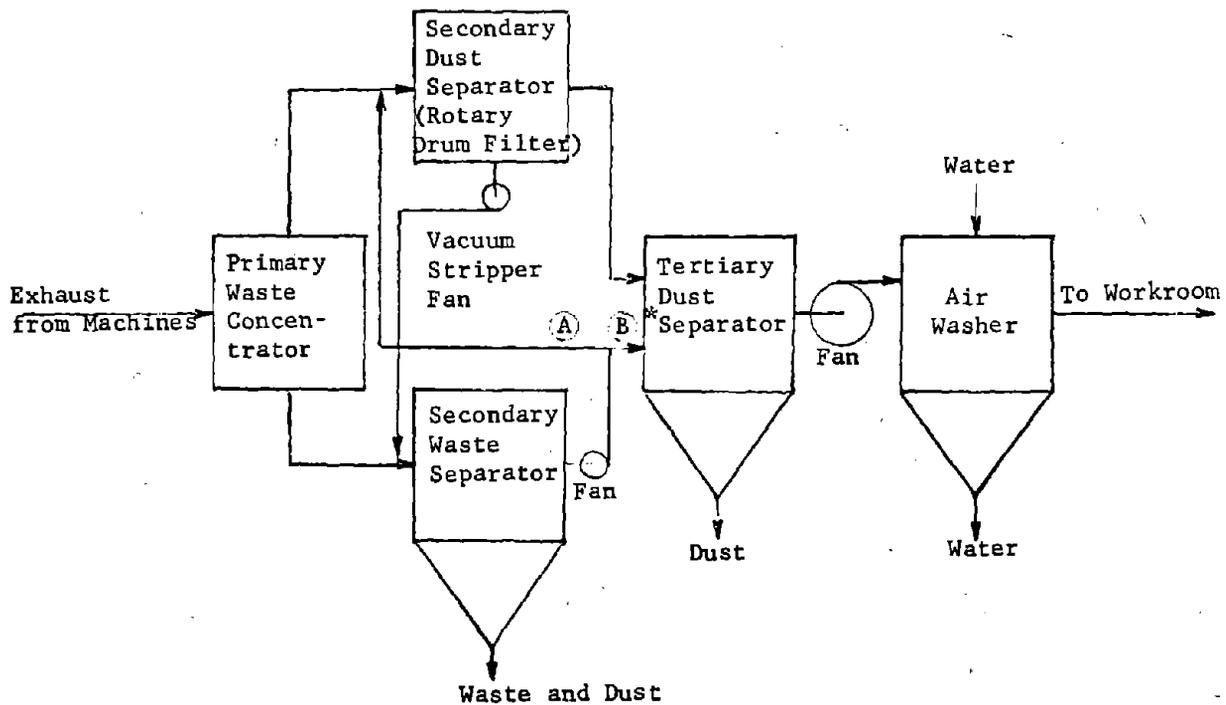


Fig. 7. System Using Rotary Drum Filter and Tertiary Dust Separators



(A) and (B) are alternate paths

*Note qualifications in text on use of Path (B)

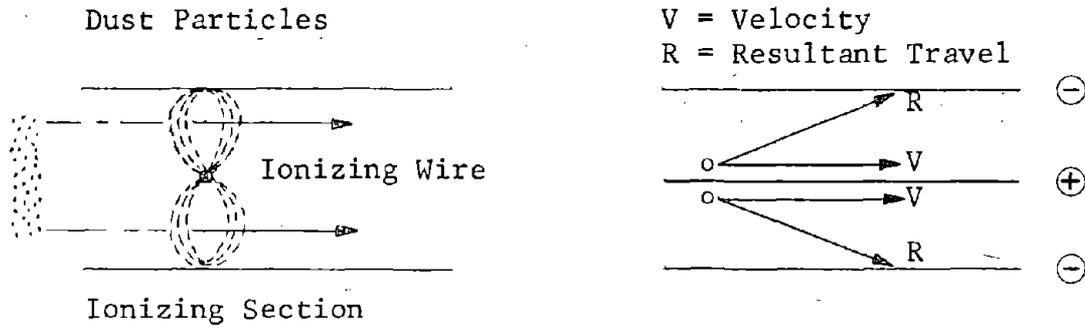


Fig. 8. Schematic Representation of a Low Voltage Precipitator.

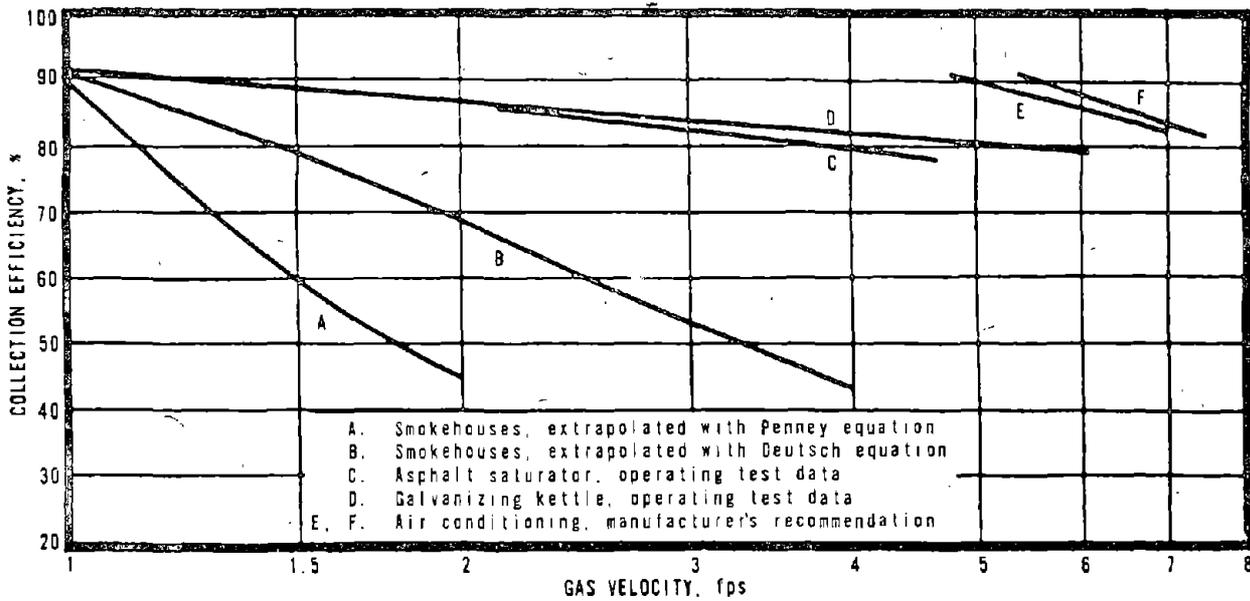


Fig. 9. Efficiency of Two-Stage Precipitator as Function of Velocity for Several Industrial Operations.

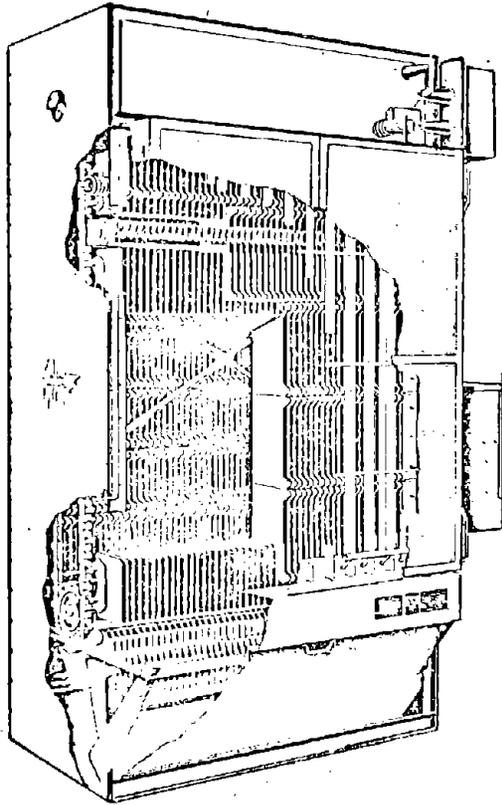


Fig. 10. Automatic Self-Cleaning,
Two-Stage Precipitator (American
Air Filter Co.).

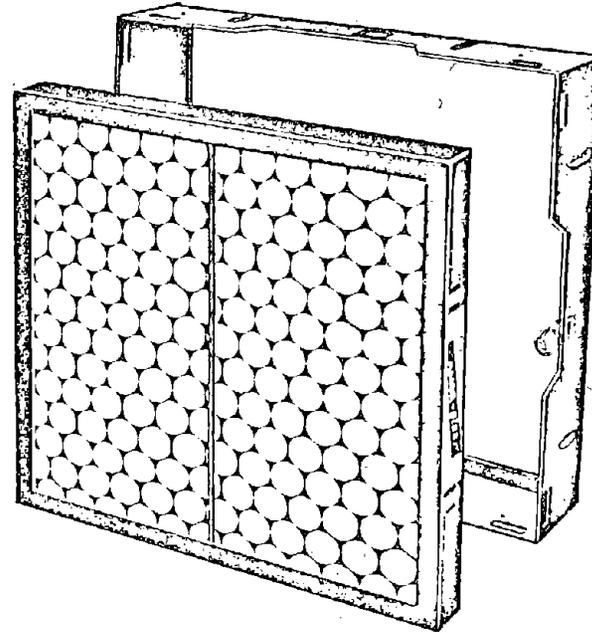


Fig. 11. Throwaway Panel Filter (American
Air Filter Co.).

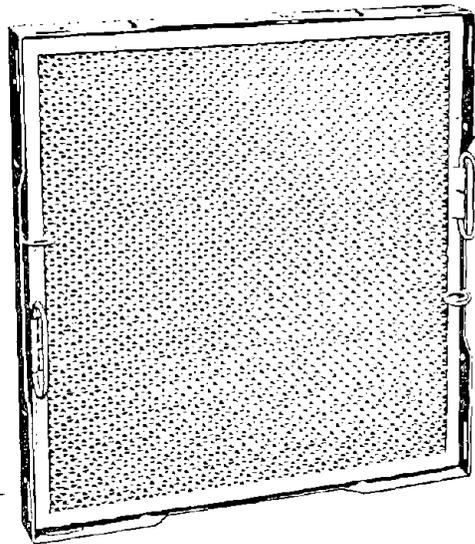


Fig. 12. Cleanable Panel Filter (American Air Filter).

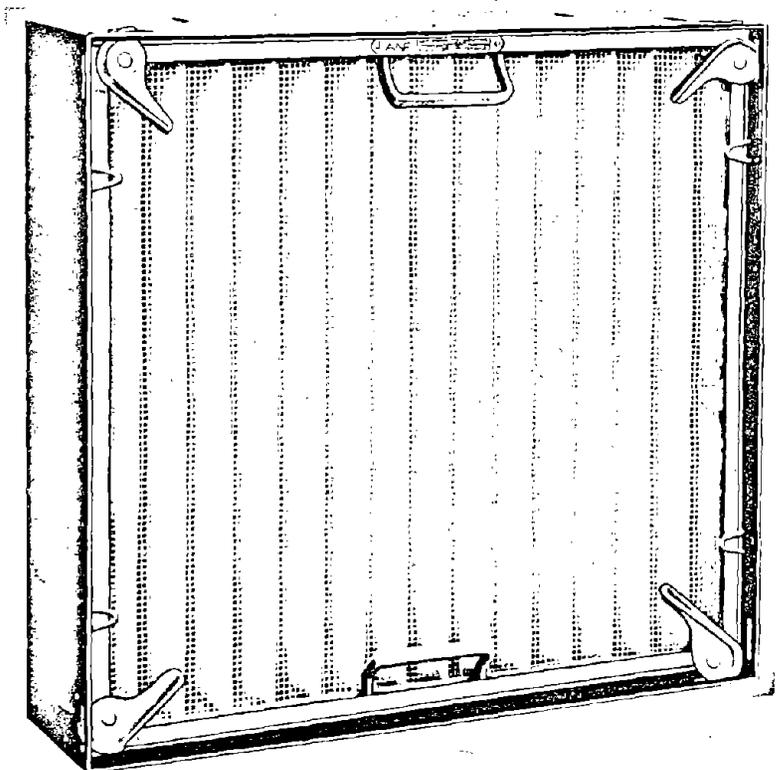


Fig. 13. Panel Filter with Replaceable Media (American Air Filter).

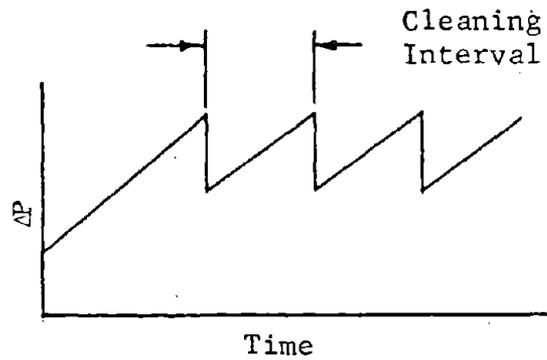


Fig. 14. Pressure Drop (ΔP) in Filters.

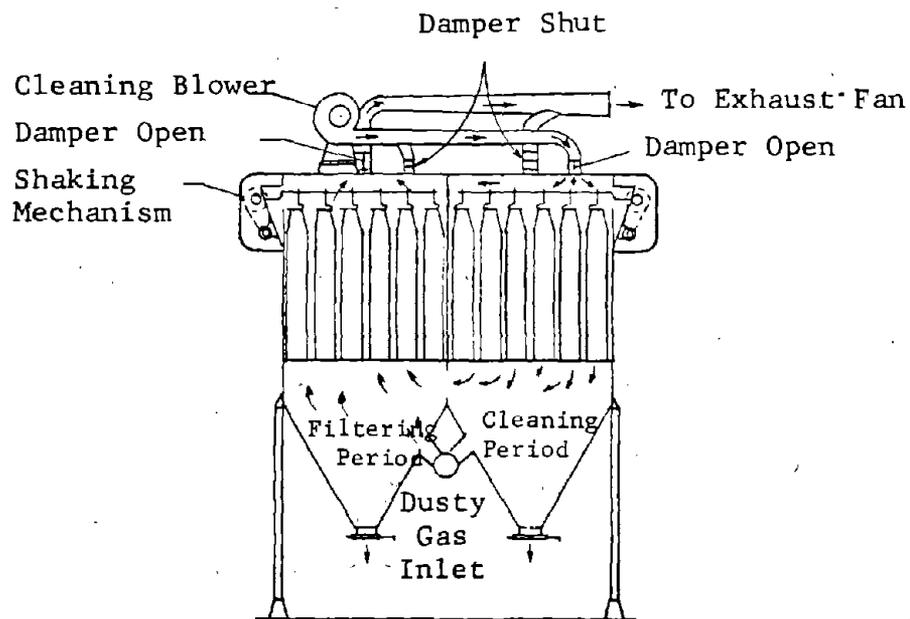


Fig. 15. Typical Bag Filter Employing Reverse Flow and Mechanical Shaking for Cleaning.

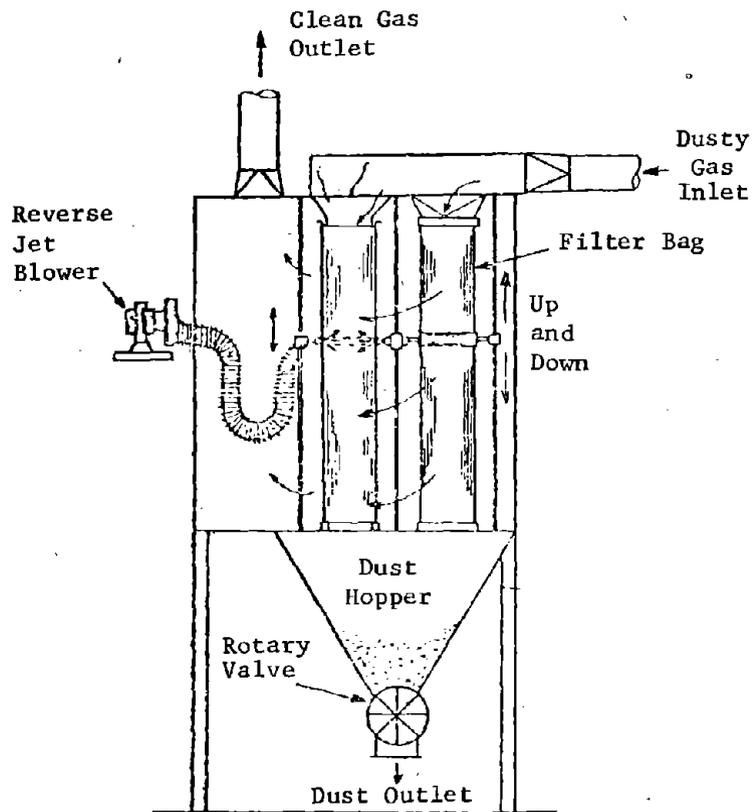


Fig. 16. Reverse-jet Filter

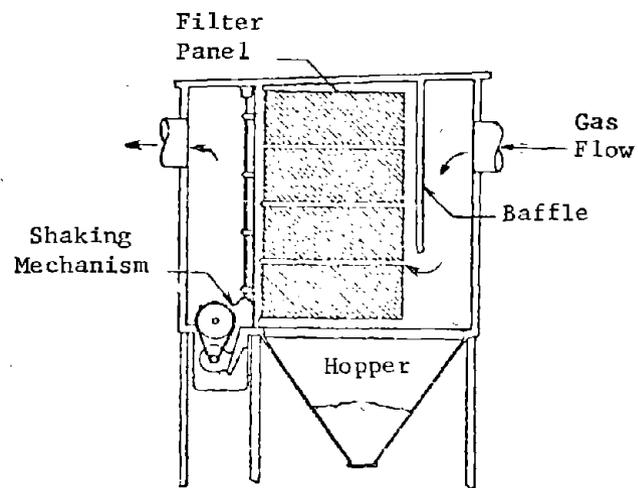


Fig. 17. Panel or Envelope Filter

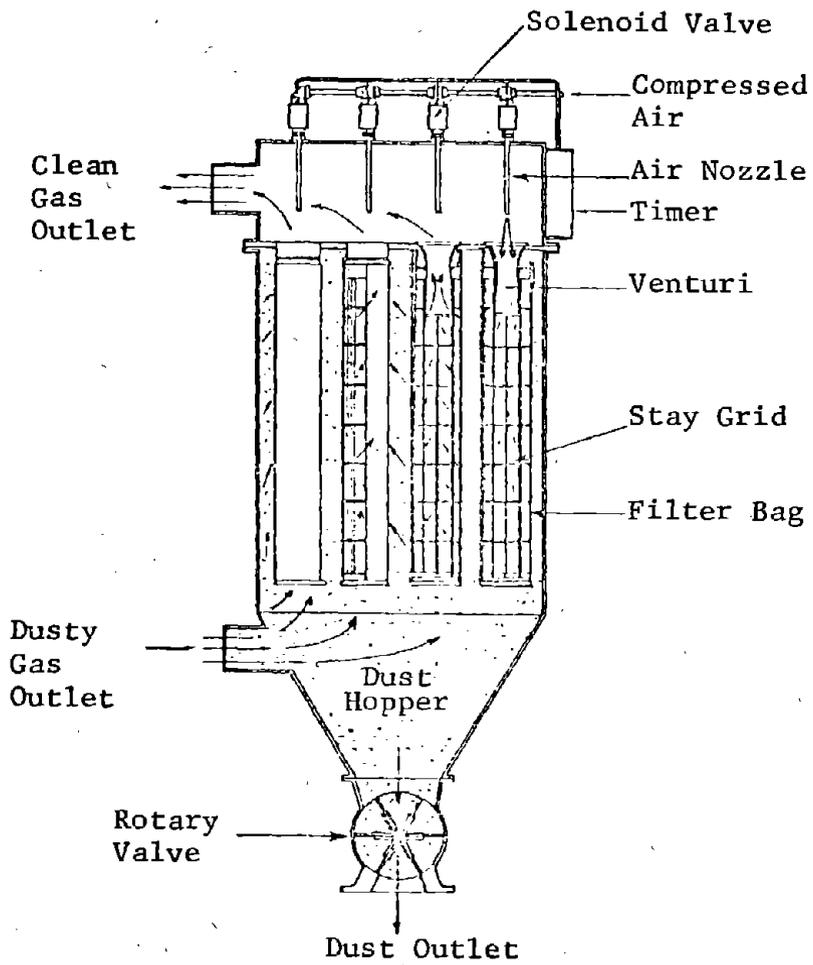


Fig. 18. Pulse-Jet Filter

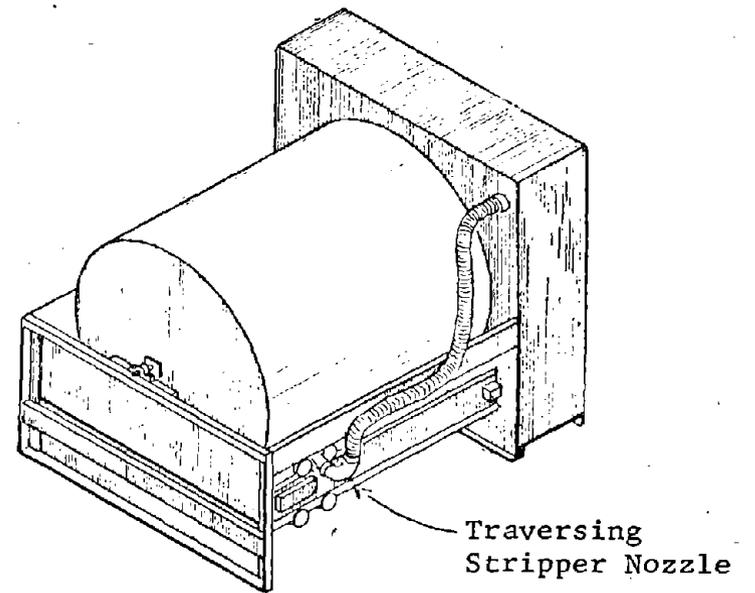


Fig. 19. Rotary Drum Filter

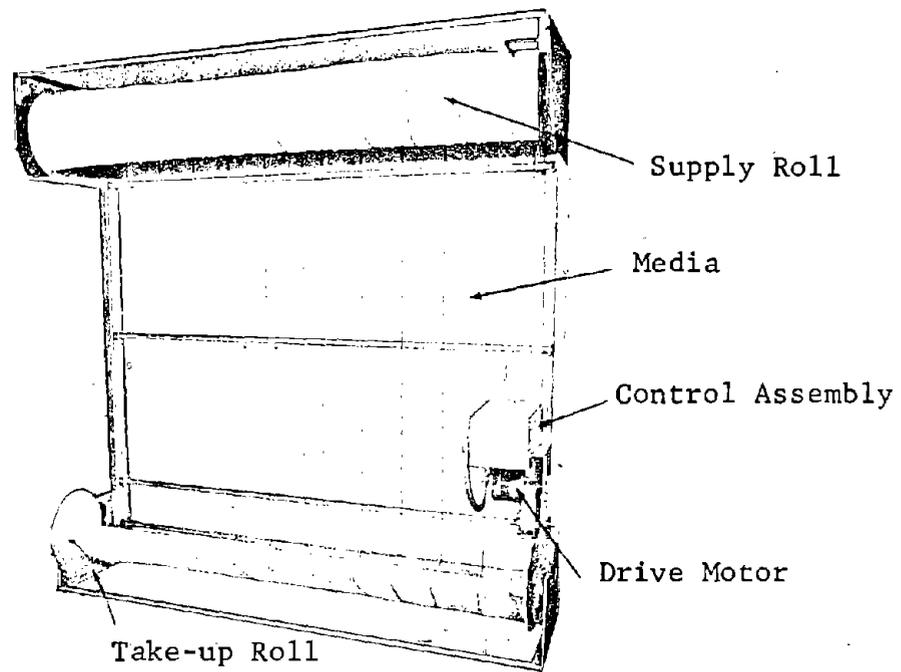


Fig. 20. Automatic Roll Filter (American Air Filter).

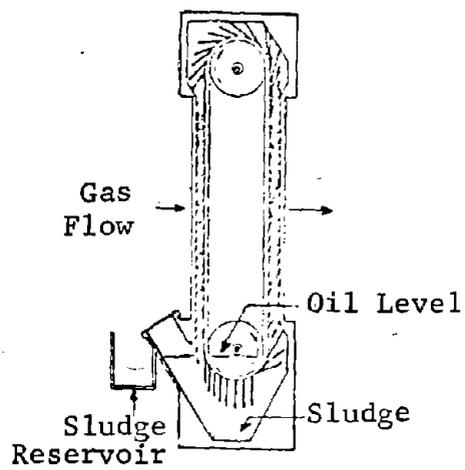


Fig. 21. Automatic - Viscous Filter.

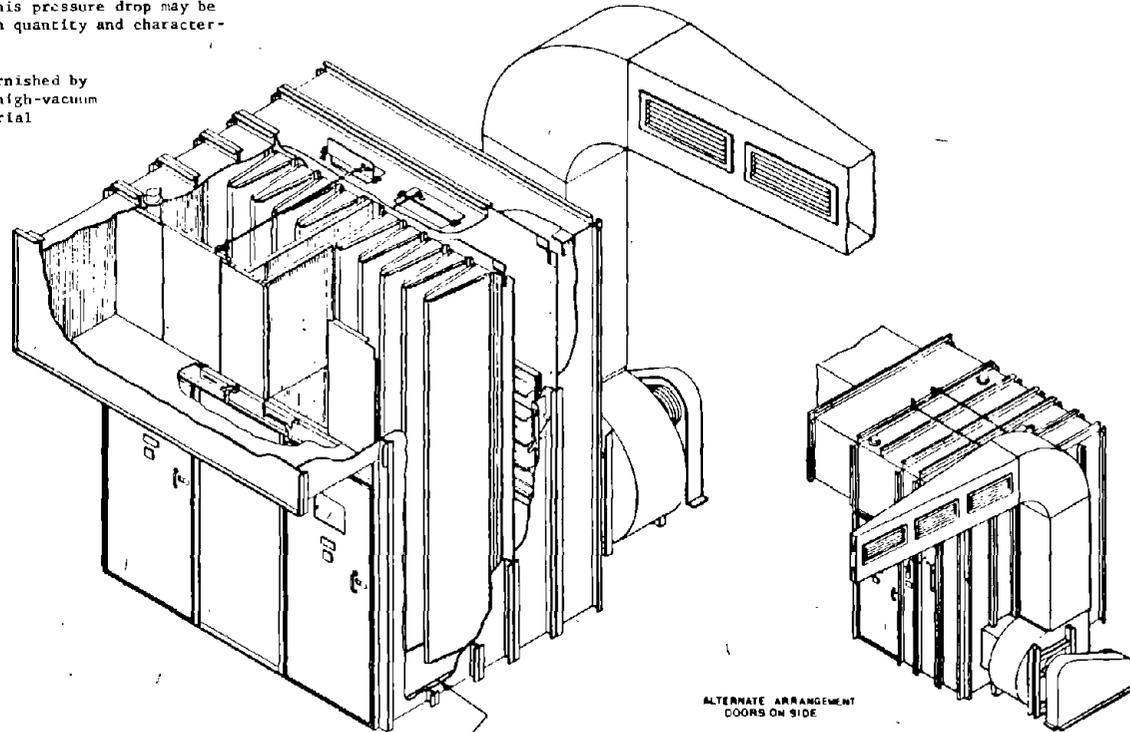
Filter-Media Material: High-loft non-woven media made of resin-bonded polyester fibers, 5/8" thick (± 1%), weighing 9.6 oz./yard, UL class Z burn rating.

Face Velocity Range: Up to 80 fpm.

Pressure Drop: 0.02" to 0.03" wg with clean media. Maximum pressure drop (dependent on mechanical structure on which media is mounted) is 4.0" wg. On regular textile applications this pressure drop may be attained in two to eight hours (depending on quantity and characteristics of the dust).

Cleaning Procedure: Use special nozzle (furnished by filter manufacturer). Best collection via high-vacuum card stripper system, if available. Industrial vacuum cleaner may also be used.

Suction system must not be shut down for cleaning if production machines are in operation. This type of filter has two compartments. Each compartment may be isolated while the media is being cleaned in the other.



Standard Overflow Arrangement.
Drains should also be installed
when units are erected.

TYPICAL FILTER FOR MANUALLY CLEANED MEDIA

Continuous-Automatic Rotary Drum Filters
(See drawing on next page)

Filter Media Material

First Stage Filter: Circular-knit pile fabric, cotton-backed with acrylic pile fact. Cotton is 43% by weight and acrylic is 57%. Face is napped. Back is coated with acrylic for stability. Weight is 13 to 14 oz./yd.

Second Stage Filter: Same as first stage except weight is 20 oz./yd., pile is 64% by weight and back is 36%.

Face Velocity Range

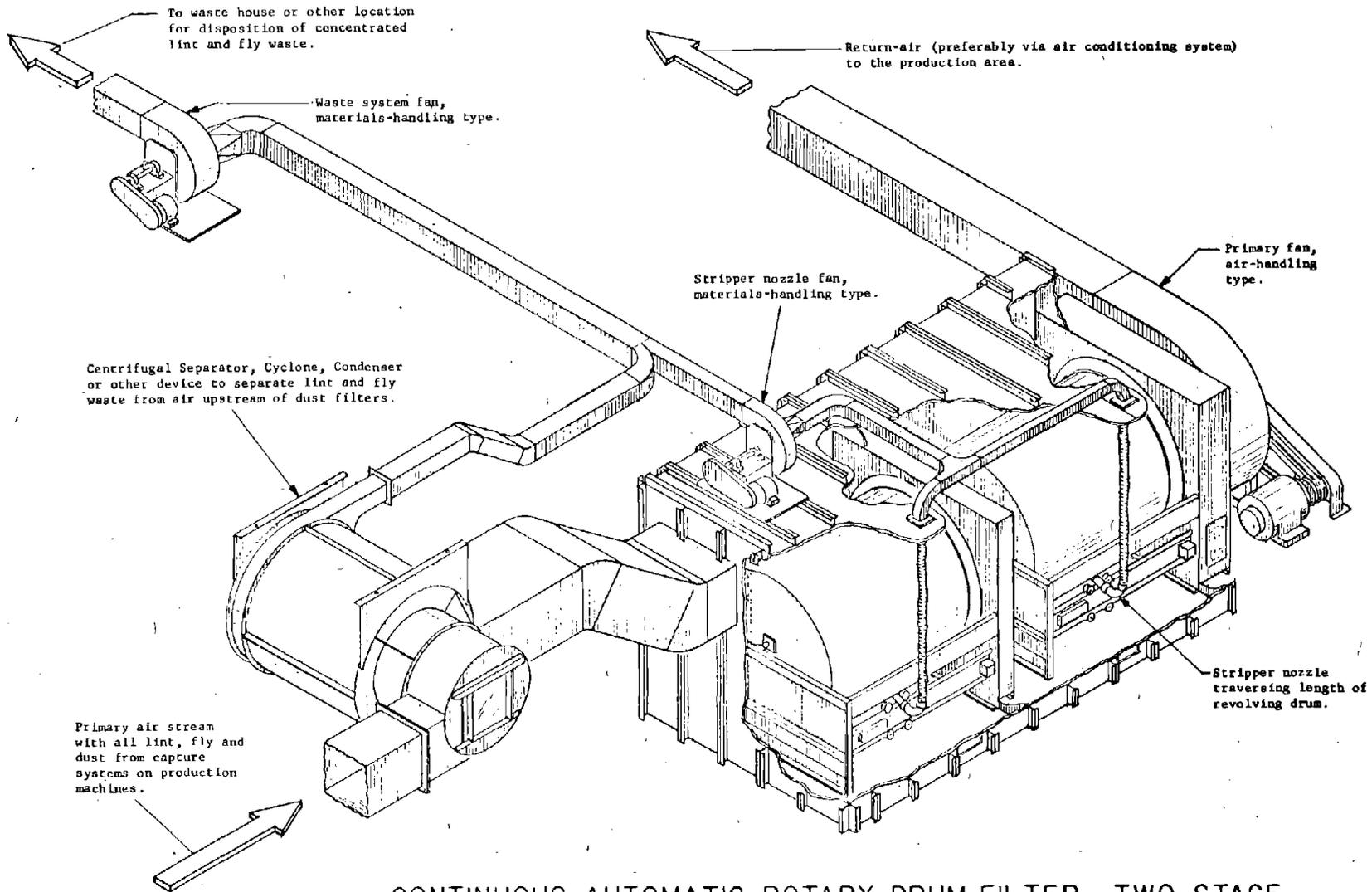
First Stage Filter: 300 fpm maximum.
Second Stage Filter: 200 fpm maximum.

Pressure Drop

First Stage Filter: 0.23" to 0.28" wg at 300 fpm face velocity (clean media). For normal operation the pressure drop should be adjusted to a desired constant level in the range of 1.0" to 2.0" wg. This is accomplished by adjustment of the speed of the drum and stripper nozzle.

Second Stage Media: 0.12" to 0.17" wg at 200 fpm face velocity (clean media). For normal operation the pressure drop should be adjusted to a desired constant level in the range of 1.8" to 2.0" wg. Adjustment is same as first stage filter.

Cleaning Procedure: Media cleaning is accomplished continuously and automatically by the combination of the revolving drum and the stripper nozzle which traverses the across the length of the drum. There is some fallout of dust which will accumulate on the floor of the filter enclosure. This should be cleared out weekly or monthly as required to prevent reintraintment. A respirator should be worn during the operation.



CONTINUOUS-AUTOMATIC ROTARY DRUM FILTER - TWO-STAGE

Description
Continuous-Automatic Lint and Dust Filter Systems

Heating and air conditioning in American cotton yarn manufacturing plants requires that air exhausted from the production areas be returned or operating costs will be prohibitively high. After the dust is captured well enough to meet the dust level required in the production environment it must be filtered out of the air so that the conditioned air may be returned to the work area.

The filtering of dust from the air can be facilitated by first separating the bulk of lint and fly waste from the air stream. This may be accomplished by various types of centrifugal separators, cyclones, automatic screening devices or textile condensers.

The need for a materials-handling system is demonstrated by the fact that a 25,000 cfm system could handle 20 cards including undercard suction. If the cards are producing 60 lbs./hr. at 4% waste this will result in about 48 lbs. per hour of waste, 384 lbs. per 8-hour shift and 1,152 lbs. in 24 hours.

This waste may be exhausted into a #6 Saco-Lowell condenser. The condenser drive can be adjusted to produce a mat of about 3" in thickness. Such a mat becomes an efficient dust filter and provides an excellent dust sink. Any dust not caught by the process may be recirculated to the first stage of the dust filters.

Removal of the bulk of lint and fly makes simple and relatively inexpensive automatic and continuous dust filtering practical. A rotary drum filter may be used for handling the high air quantities containing some fly and large quantities of dust. The air passes through the filter media (which is stretched around the outside of the drum) from outside to inside. The drive unit continuously traverses the suction stripper nozzle back and forth across the length of exposed media on the surface of the drum.

The dust which is collected on and in the filter media on the revolving drum is vacuumed out of the media by the stripper nozzle. It may then be blown into the duct conveying waste from the preseparator to the #6 condenser. It will be filtered by the thick mat in the condenser and any that penetrates that mat may be recirculated to the first stage filter.

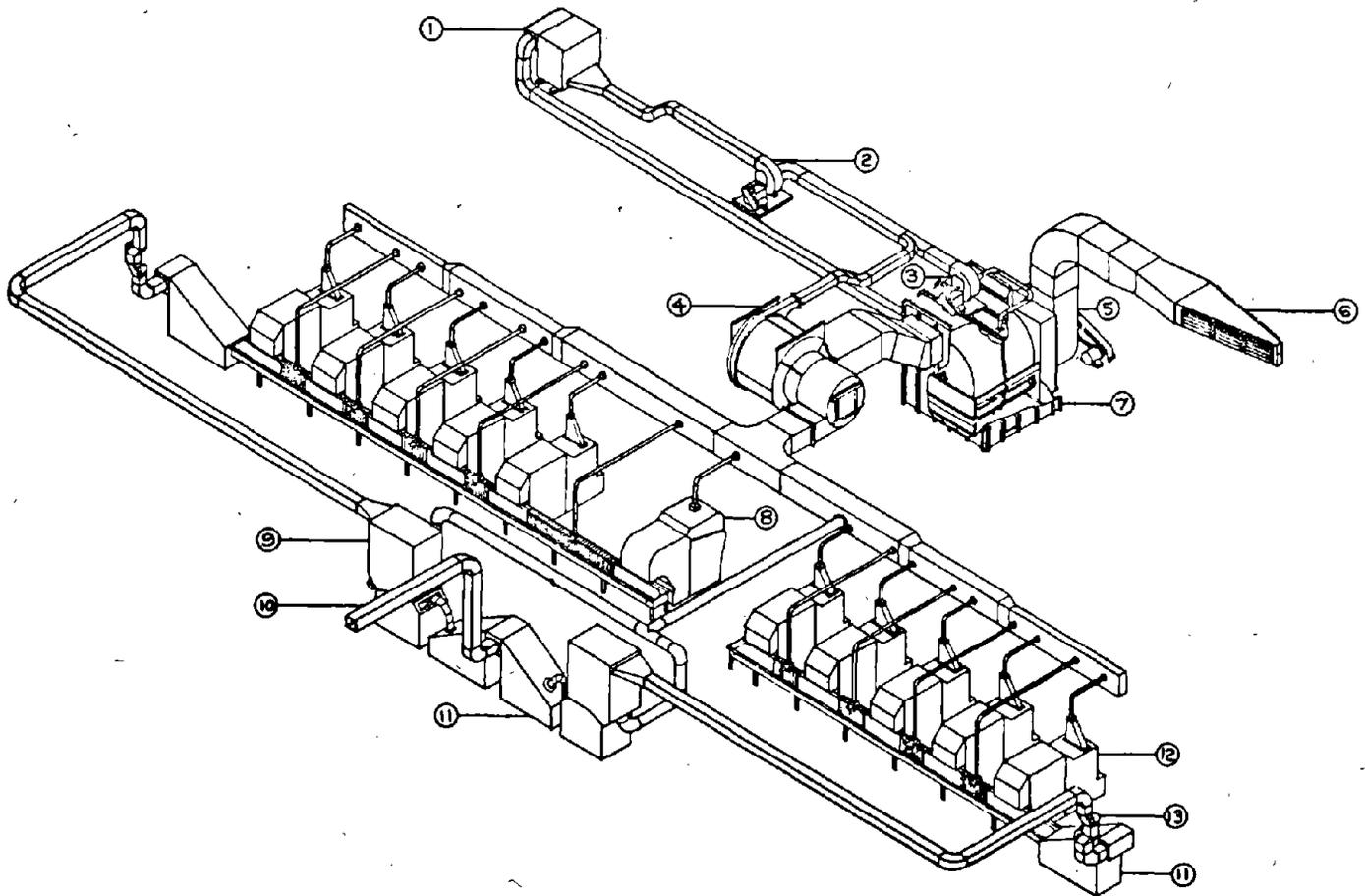
A characteristic of this type of filter is its ability to operate continuously at an even pressure drop. This is the result of cleaning a small area of the filter media but doing it continuously. The low and constant pressure drop makes it economical to use such filters in tandem for increased efficiency.

Two-stages of dust filters are required only for systems handling high dust loadings. When the lint and dust control system air can be recirculated to the room via the air conditioning apparatus room and through good air conditioning filters, two-stage dust filtration is accomplished without tandem filters in the dust control system. In this arrangement, however, the engineer must take into account the increased cost of maintenance and filter media replacement on the AC filters.

Many of the drawings in this report picture these systems arranged for return of the air directly to the production area. This is not, of course, the best way to do it. Performance of both the dust control and the air conditioning systems will be improved if they are properly coordinated and work together. Ideally the dust control systems should serve as the return-air system for air conditioning. When the two are equal in air quantity the air flow and distribution in the production area is optimized.

Typical Lint and Dust Control System for Opening
(see drawing on next page)

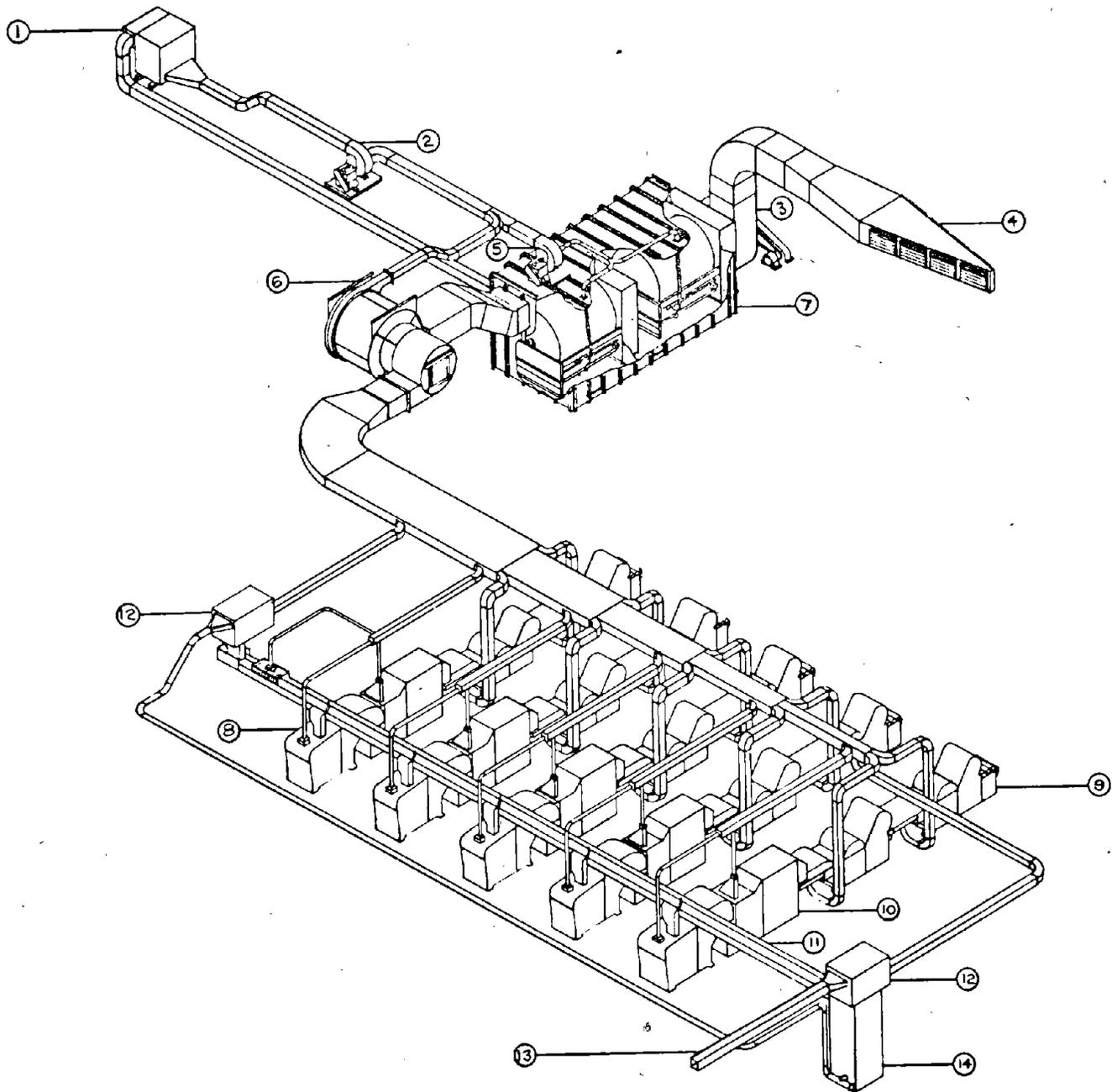
1. #6 condenser which separates lint waste and deposits it into a suitable container.
2. Material (waste) handling fan.
3. Stripper nozzle fan which supplies vacuum for cleaning media on rotary drum filter.
4. Preseparator which concentrates the lint waste into about 10% of the primary air quantity.
5. Primary air-handling fan.
6. Diffusor-head returning air directly to the room.
7. Rotary drum dust filter (single-stage) in metal enclosure.
8. Waste feeder hopper for blending reworkable waste into the cotton stock mixture.
9. #11/12 lattice opener.
10. Duct for pneumatic transportation of cotton stock to the picker room.
11. Superior cleaner to remove trash, seeds, and other objectionable matter from the cotton stock.
12. Blending feeder hopper for manually feeding specified quantities of various types and grades of cotton into the opening process.
13. Metal separation magnet to remove iron and steel trash which can damage production machines and start fires.



Typical Lint and Dust Control System for Opening
(Continuous-Automatic Type)

Typical Lint and Dust Control Systems for Picking
(see drawing on next page)

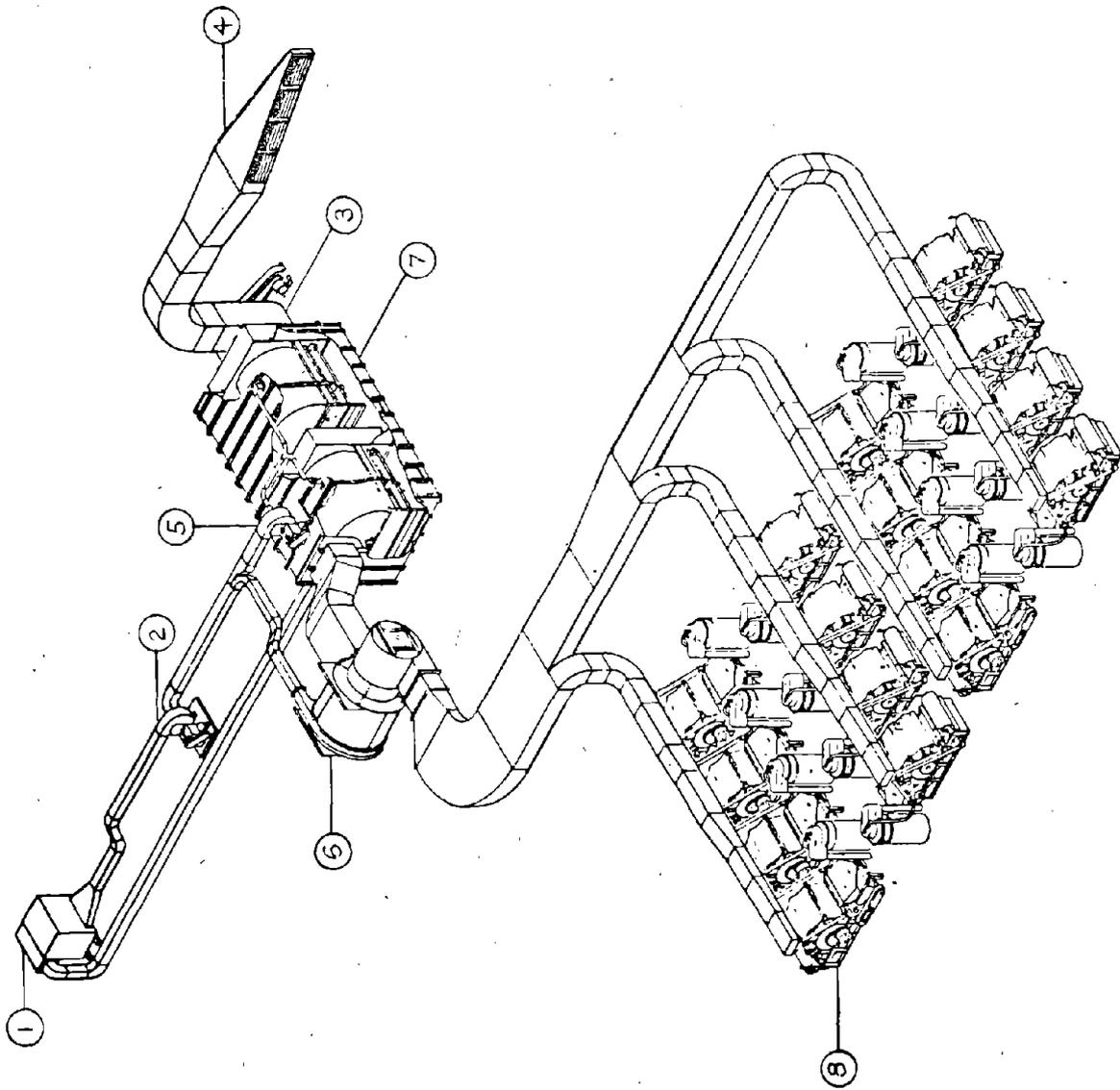
1. #6 condenser which separates lint waste and deposits it into a suitable container.
2. Material (waste) handling fan.
3. Primary air-handling fan.
4. Diffusor-head returning air directly to the room.
5. Stripper nozzle fan which supplies vacuum for cleaning media on rotary drum filter.
6. Preseparator which concentrates lint waste into about 10% of the primary air quantity.
7. Rotary drum dust filter (two-stage) in metal enclosure.
8. Feeder hopper
9. Two-beater picker
10. Reserve feeder hopper
11. Automatic belt or rake distributor
12. Condenser to receive stock from overflow reserve box and drop stock onto rake distributor.
13. Duct for pneumatic transportation of stock from opening process to picking process.
14. Overflow reserve box.



Typical Lint and Dust Control System for Picking
(Continuous-Automatic Type)

Typical Lint and Dust Control System for Carding
(see drawing on next page)

1. #6 condenser which separates lint waste and deposits it into a suitable container.
2. Material (waste) handling fan.
3. Primary air-handling fan.
4. Diffusor-head returning air directly to the room.
5. Stripper nozzle fan which supplies vacuum for cleaning media on rotary drum filter.
6. Preseparator which concentrates lint waste into about 10% of the primary air quantity.
7. Rotary drum dust filter (two-stage) in metal enclosure.
8. High speed card equipment with double-connected doffer plenum, single-connected lickerin plenum, undercard plenum and coiler trumpet suction nozzle (1400 cfm per card).



Typical Lint and Dust Control System for Carding
 (Continuous-Automatic Type)

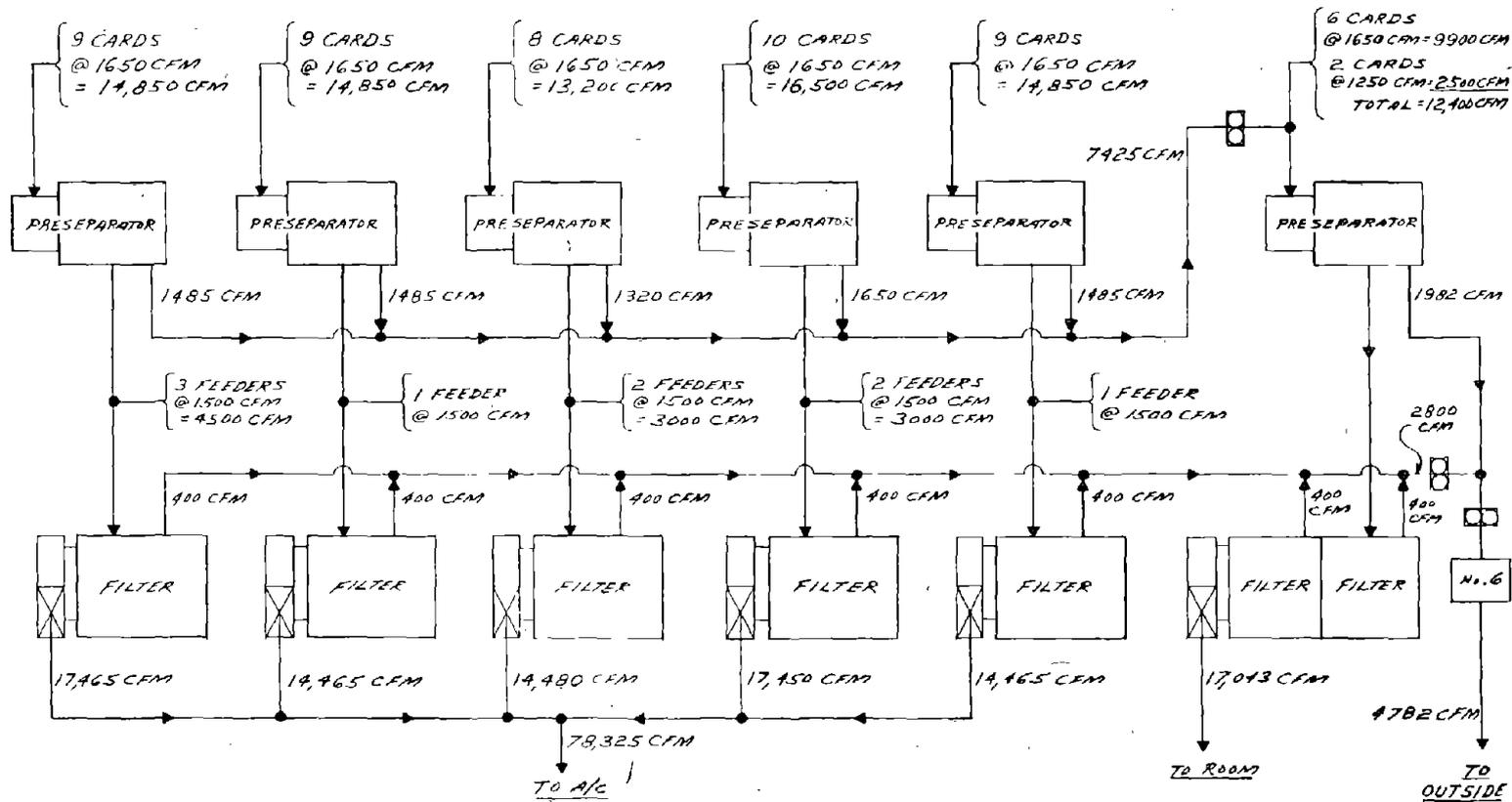
Two-Stage Filter
at
Mill Code #8

The "Filter System Schematic" drawing which follows shows the arrangement and function of this filter in the card room lint and dust control system in this mill. Incidentally, this is a later modification of the card room previously described under "Dust Control System on Cards at Mill Code #8".

The two-stage rotary drum filter which was the subject of this study served one of six groups of cards. In addition, the lint and fly waste from all of the other five systems was directed to the preseparator in this system #6. This preseparator-filter-filter combination, therefore, handled the concentrated waste from a total of fifty-three high speed cards. A two-stage filter was specified for this system because of the abnormally high dust level that it must handle plus the fact that the air from this system must return directly to the card room (rather than via the air conditioning filters and apparatus room).

Both stages of the filter were 5.5 feet in diameter and 6 feet long with a face area of 96.52 square feet each. They were handling a total of 17,043 cfm at a face velocity of 177 fpm.

In the data which follows, all efficiency calculations are based on the average value of the samples taken that day. All dust samples follow the procedure described in the appendix to this report. The drum and stripper nozzle speed shown in the data were machine settings. The explanations describe actual operation during sampling.



SYSTEM No. 1

SYSTEM No. 2

SYSTEM No. 3

SYSTEM No. 4

SYSTEM No. 5

SYSTEM No. 6

SCHEMATIC MILL CODE 8 CARD ROOM

TWO-STAGE FILTER AT MILL CODE #8 – DATA SUMMARY

Date	4/30/73	5/3/73	5/17/73	5/18/73	5/22/73	5/23/73	5/28/73	5/29/73	5/30/73	6/7/73	6/8/73
Explanation	#1	#1	#2	#3	#4	#4	#5	#6	#6	#7	#7
First Stage Filter											
Media	M1	M1	M1	M1	M1	M1	M1	M1	M1	M1	M1
ΔP ("wg)	0.9	0.9	1.5/2.5	1.5/2.0	1.1/1.9	1.8/1.9	1.6/1.8	1.6/1.8	1.5/1.7	1.8/1.9	1.8/2.0
Drum RPM	4.77	4.77	4.77	4.77	4.77	4.77	4.77	4.77	4.77	4.77	4.77
Nozzle Speed (in./min.)	7.35	7.35	7.35	7.35	1.84	1.84	1.84	1.84	1.84	1.84	1.84
Dust Samples (mg/m ³) Upstream											
Number	1	1	4	7	2	7	1	1	3	5	2
Minimum	—	—	9.93	11.40	11.14	10.86	—	—	14.58	11.44	16.7
Average	17.71	6.43	11.47	14.75	13.90	12.50	21.25	11.98	16.30	13.2	16.9
Maximum	—	—	12.69	22.07	16.74	13.99	—	—	17.22	14.66	17.1
% Efficiency	85.8	82.0	95.8	96.1	94.2	94.1	96.4	93.9	95.4	93.7	94.1
Second Stage Filter											
Media	M1	M1	M1	M1	M1	M1	M2	M2	M2	M2	M2
ΔP ("wg)	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.7	1.4/1.6	1.1	1.1
Drum RPM	4.77	4.77	4.77	4.77	4.77	4.77	4.77	4.77	4.77	4.77	4.77
Nozzle Speed (in./min.)	7.35	7.35	7.35	7.35	7.35	7.35	7.35	7.35	7.35	7.35	7.35
Dust Samples (mg/m ³) Upstream											
Number	1	1	6	5	7	5	2	2	4	4	2
Minimum	—	—	0.21	0.36	0.69	0.65	0.74	0.67	0.70	0.69	0.84
Average	2.51	1.16	0.48	0.57	0.81	0.74	0.77	0.73	0.75	0.83	1.00
Maximum	—	—	0.77	0.90	1.18	0.81	0.80	0.78	0.78	0.97	1.17
% Efficiency	62.7	17.2	43.6	38.6	18.5	18.9	51.3	67.1	82.7	81.6	85.6
Discharge Duct											
Dust Samples (mg/m ³)											
Number	1	1	5	5	7	5	2	2	4	4	2
Minimum	—	—	0.19	0.24	0.62	0.57	0.36	0.22	0.11	0.13	0.11
Average	0.94	0.96	0.27	0.35	0.66	0.60	0.38	0.24	0.13	0.15	0.15
Maximum	—	—	0.34	0.49	0.69	0.63	0.39	0.25	0.17	0.19	0.18
Overall Efficiency %	94.7	85.1	97.6	97.6	95.3	95.2	98.2	98.0	99.2	98.8	99.1

TWO-STAGE FILTER AT MILL CODE #8 – DATA SUMMARY (Continued)

Date	6/11/73	6/13/73	6/14/73	6/18/73	6/20/73	6/21/73	6/22/73	7/10/73	7/11/73	7/13/73
Explanation	#7	#7	#7	#7	#8	#8	#8	#9	#9	#9
First Stage Filter										
Media	M1									
ΔP ("wg)	1.8/2.0	1.9/2.0	1.4/1.9	1.7	1.0/1.1	1.0/1.1	1.0/1.1	1.8	1.8	1.8
Drum RPM	4.77	4.77	4.77	4.77	4.77	4.77	4.77	4.77	4.77	4.77
Nozzle Speed (in./min.)	1.84	1.84	1.84	1.84	7.35	7.35	7.35	1.84	1.84	1.84
Dust Samples (mg/m ³) Upstream										
Number	5	3	9	2	2	7	5	10	14	3
Minimum	12.14	14.04	12.68	15.32	10.68	7.35	10.95	13.53	9.3	12.23
Average	14.20	15.10	15.80	15.58	11.11	12.99	12.09	15.94	13.3	13.47
Maximum	16.02	16.35	18.11	15.84	11.54	15.47	13.54	19.15	15.87	15.54
% Efficiency	94.5	95.2	95.1	95.7	89.4	93.1	92.0	95.1	94.7	94.5
Second Stage Filter										
Media	M2									
ΔP ("wg)	0.9/1.1	0.9/1.1	1.5/1.7	1.5	1.5	1.5	1.5/1.6	2.0	2.0	2.0
Drum RPM	4.77	4.77	4.77	4.77	4.77	4.77	4.77	4.77	4.77	4.77
Nozzle Speed (in./min.)	7.35	7.35	7.35	7.35	7.35	7.35	7.35	7.35	7.35	7.35
Dust Samples (mg/m ³)										
Number	5	5	4	2	4	5	6	5	8	3
Minimum	0.71	0.49	0.73	0.61	1.00	0.82	0.81	0.71	0.63	0.55
Average	0.78	0.72	0.78	0.67	1.18	0.89	0.97	0.78	0.71	0.74
Maximum	0.84	0.79	0.83	0.73	1.37	1.09	1.12	0.92	0.84	0.92
% Efficiency	78.4	73.2	78.2	73.1	77.5	76.7	79.1	79.0	84.3	82.5
Discharge Duct										
Dust Samples (mg/m ³)										
Number	5	5	4	2	4	5	6	5	8	3
Minimum	0.07	0.15	0.16	0.17	0.20	0.17	0.14	0.13	0.09	0.08
Average	0.17	0.19	0.17	0.18	0.27	0.21	0.20	0.16	0.11	0.13
Maximum	0.29	0.26	0.18	0.19	0.33	0.25	0.34	0.21	0.13	0.17
Overall Efficiency %	98.8	98.7	98.9	98.9	97.6	98.4	98.3	99.0	99.2	99.0

Two-Stage Filter at Mill Code #8 - Data Summary (continued)

Explanation #1

No changes. All equipment set up as originally installed.

Explanation #2

First stage drum and nozzle in motion intermittently by manual control to hold pressure drop within range of 1.5" to 2.5" wg on first stage.

Explanation #3

First stage drum and nozzle in motion intermittently by manual control to hold pressure drop within range of 1.5" to 2.0" wg on first stage. Second stage drum and filter stopped during this test.

Explanation #4

First stage nozzle slowed to 1/4 original speed. Second stage drum and filter stopped during this test.

Explanation #5

Type M2 media installed on second stage filter. All drums and stripper nozzles in operation.

Explanation #6

Second stage drum and nozzle stopped during this test.

Explanation #7

Second stage drum and stripper nozzle motion controlled by pressure switch.

Explanation #8

Drive on first stage stripper nozzle changed back to original speed. Second stage drum and stripper nozzle motion controlled by pressure switch.

Explanation #9

Drive on first stage stripper nozzle changed to slower speed. Second stage drum and stripper nozzle controlled by pressure switch.

Manually Cleaned Filter
at
Mill Code #26

Please see the preceding report entitled "Dust Control System on Combers at Mill Code #26". That report describes the cotton stock, the production machinery and arrangement, the lint and dust capture system and the duct, filter and return air systems on combers in that mill. The lint and dust control system is illustrated by the "Comber System Layout" drawing. Sampler locations #5 and #6 are also shown on that drawing. Sampling with high-vol. instruments at these two locations gives a measure of the filter efficiency. A summary of this data is shown in the system report which indicates an efficiency of 95%.

The filter is illustrated in the system report by the "Manually Cleaned Filter" drawing and values for face area, pressure drop (clean) and average air quantity are given. At the time of these tests the filter was operating at 20,070 cfm/321 sq. ft. = 64.33 fpm face velocity average.

The filter in Mill Code #26 was very well maintained and when this is the case, such filters are effective. They are best applied to high-lint, low-dust applications such as combers, warpers, and spoolers.

Cotton Dust Sampling Procedure
with
Vertical Elutriators

Instrument Calibration Procedure

Prior to each series of tests, the air flow rates of all air samplers used in the tests should be verified.

The critical orifice used to maintain the air flow rate on the vertical elutriator is designed for a nominal flow of 7.4 liters per minute when operated at a pressure differential of 15" Hg. However, due to variances in manufacture, actual flow rates vary somewhat from the nominal. The actual flow rate of each orifice should be determined and this value used in all computations.

The flow rate is checked with a Wet Test Meter No. 63111. See the drawing that follows "Test Set-up for Calibrating Critical Orifices" and the manufacturer's instructions for use of the Wet Test Meter. Note that a filter cassette is placed in series with the critical orifice under test in the same relationship as when the orifice is installed in a vertical elutriator. During calibration, the vacuum should be adjusted and maintained at 15" Hg. by adjusting the vacuum relief valve. Minimum time for each test run shall be 10 minutes.

Assembly of Filter Cassette (see drawing that follows, "Filter Cassette Assembly")

1. Loosely assemble 3-piece cassette.
2. Number cassette, top and bottom.
3. Desiccate filter minimum of 12 hours.
4. Place absorbant pad in cassette.
5. Weigh filter. (Use Mettler Model H-20 Balance. 0.01 mg accuracy)
6. Place filter in cassette.
7. Record weight of filter in log, using cassette number to identify.
8. Fully assemble cassette, using pressure to force parts tightly together.
9. Install plugs top and bottom.
10. Put shrink band on cassette, covering joint between center and bottom parts of cassette.
11. Set cassette aside until shrink band dries thoroughly.

Sampling Procedure

1. Install vertical elutriator in worker's environment, with inlet 5 feet from floor (see drawing that follows, "Vertical Elutriator Installation").
2. Remove top section of cassette.

3. Install cassette in ferrule of elutriator.
4. Tape cassette to ferrule with 1" wide masking tape or similar material for air-tight seal.
5. Remove bottom plug of cassette and attach hose containing critical orifice.
6. Start elutriator pump and check to see if gauge reads 15" vacuum.
7. Record starting time along with cassette number.
8. At end of sampling period (a minimum of 6 hours and preferably 8 hours), stop pump and record time.
9. Remove cassette from elutriator and replace top section of cassette and bottom plug.
10. Controls

With each batch of samples collected, two additional filters should be subjected to exactly the same handling as the samples except that they are not opened. These control filters are desiccated and reweighed the same as the sample filters. Any difference in weight in the control filters is used as a correction factor for all samples in that batch.

Example:

<u>Original Weight</u>	<u>Reweighed</u>	<u>Difference in Weight</u>	<u>Correction Factor</u>
15.50	15.52	.02	$.02 + .04 = \frac{.06}{2} = .03$
17.60	17.64	.04	

When the average of the weight difference is positive, the correction factor is subtracted from the weight of the sample, and when negative the correction factor is added to the weight of the sample.

Weighing Sample

1. Remove shrink band.
2. Remove top section of cassette and bottom plug.
3. Desiccate sample, with filter still in bottom part of cassette for a minimum of 12 hours.
4. Remove filter from cassette and weigh. (Use Mettler Model H-20 Balance)
5. Record weight in log against original weight.

Determining Air Quantity

1. From starting and stopping times of sampling period, determine length of time in minutes of sampling period.

2. Multiply sampling time in minutes by flow rate of critical orifice in liters per minute and divide by 1000 to find air quantity in cubic meters.

Example:

Starting time: 8:53 am

Stopping time: 2:53 pm

Flow rate of critical orifice: 7.4 liters per minute

8:53 to 2:53 = 6 hours = $360 \times 7.4 = 2664 \div 1000 = 2.664 \text{ m}^3$

Calculating Dust Concentration

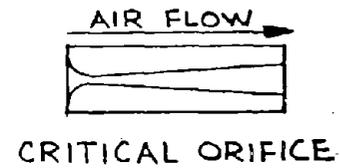
1. Subtract weight of clean filter from dirty filter and apply correction to find actual weight of sample. Record this weight in mg. in log.
2. Divide weight of sample by air quantity in cubic meters to find dust concentration in mg/m^3 .

Example:

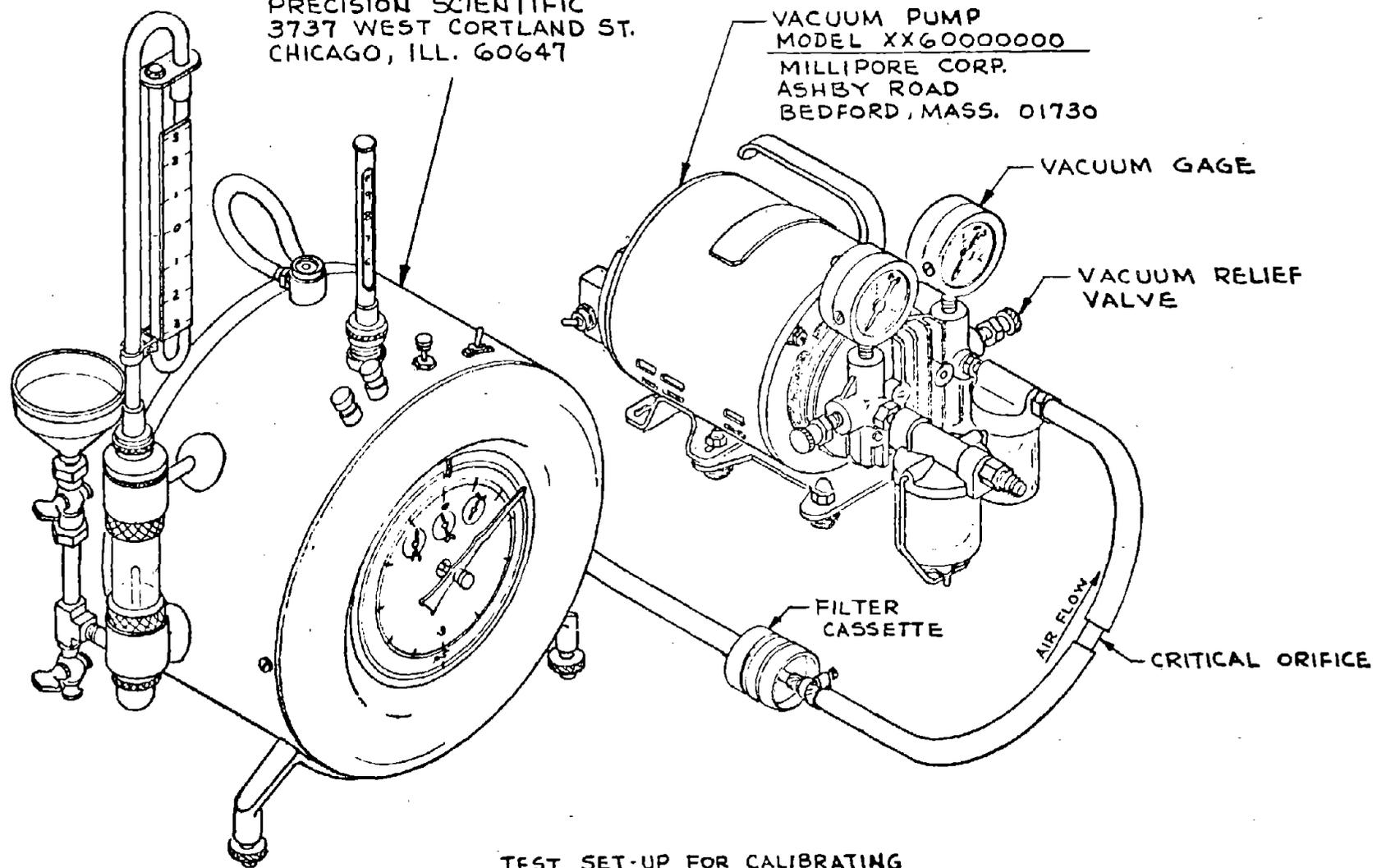
Air Quantity	2.664 m^3
Dirty Filter	16.71
Clean Filter	<u>15.48</u>
	1.23
Correction Factor	<u>.02</u>
	1.21 mg

$1.21 \div 2.664 = 0.45 \text{ mg}/\text{m}^3$ dust concentration

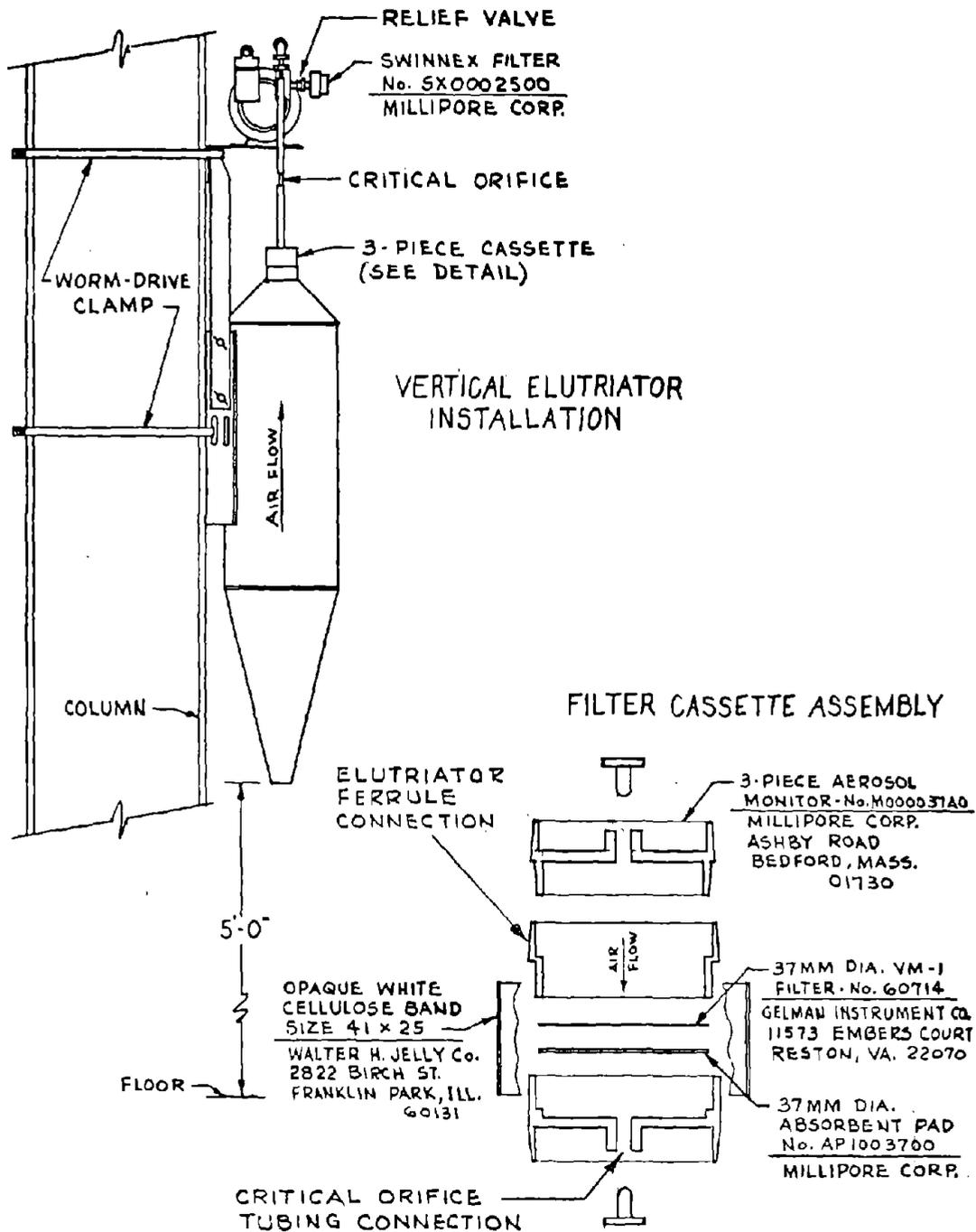
WET TEST METER
No. 63111
PRECISION SCIENTIFIC
3737 WEST CORTLAND ST.
CHICAGO, ILL. 60647



VACUUM PUMP
MODEL XX60000000
MILLIPORE CORP.
ASHBY ROAD
BEDFORD, MASS. 01730



TEST SET-UP FOR CALIBRATING
CRITICAL ORIFICES



**Cotton Dust Sampling Procedure
with
High Volume Samplers**

Instrument Calibration Procedure

Prior to each series of tests, the air flow rates of all air samplers used in the tests should be verified. The test set-up for calibrating high volume samplers used in the filter studies is shown on the drawing that follows, "Test Set-up for Calibrating High Volume Air Samplers."

Variation in air flow rate is accomplished by varying the speed of the sampler motor by means of the variable transformer. A minimum of 4 points shall be checked in the flow rate range of 20 to 30 CFM. The measured pressure differential across the orifice plate assembly is used to determine actual air flow rates by means of the calibration curve for the orifice plate being used. Appropriate adjustment of the calibration damper shall be made as required.

Pre-weighing

1. Stamp identifying number with rubber stamp on back side of filter.
2. Desiccate filter minimum of 12 hours.
3. Weigh filter. (Use Mettler Model H-20 Balance. 0.01 mg accuracy)
4. Record weight of filter in log.
5. Place filter in individual clear plastic bag.

Sampling Procedure

1. Install filter in sampler with numbered side toward screen support.
2. Start pump motor.
3. Record start time and sampling air quantity.
4. At end of sampling period, record stop time and sampling air quantity.
5. Carefully remove filter from sampler, fold so that identifying number may be seen and dust is contained inside of folds.
6. Place folded filter in glassine envelope.

Weighing Procedure

1. Remove filter from glassine envelope.
2. Carefully unfold so as not to lose any collected dust from surface of filter.
3. Desiccate sample for minimum of 12 hours.
4. Weigh filter. (Use Mettler Model H-20 Balance. 0.01 mg accuracy)

5. Record weight of filter in log.
6. Return filter to glassine envelope for filing.

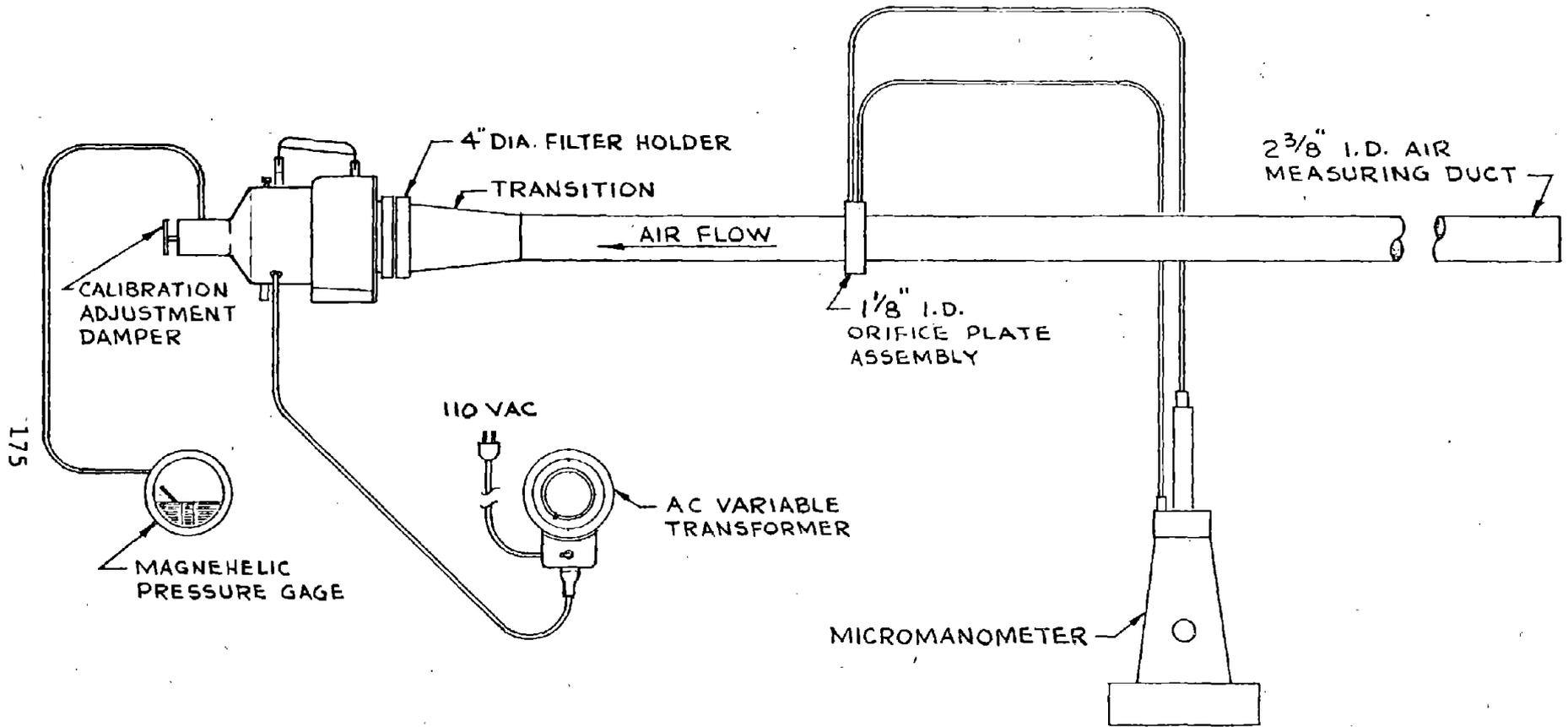
Filter Media Efficiency - Sampling Procedure

Upstream Side of Filter Media (see the Unico Model 550 Drawings that Follow)

Locate sampler inside of filter housing on "dirty" side of media being tested. For total dust and lint measurements, the sampler shall be operated "open-faced" facing the air stream. For dust-only tests, lint shall be excluded from the sample by installing a 4 in. diameter, 12 in. long wire mesh screen cylinder in front of the sampler. Depending on the lint concentration in the air stream it may be necessary to remove accumulated lint from the screen cylinder during the sampling period.

Downstream Side of Filter Media (see the Unico Model 550 drawings that Follow)

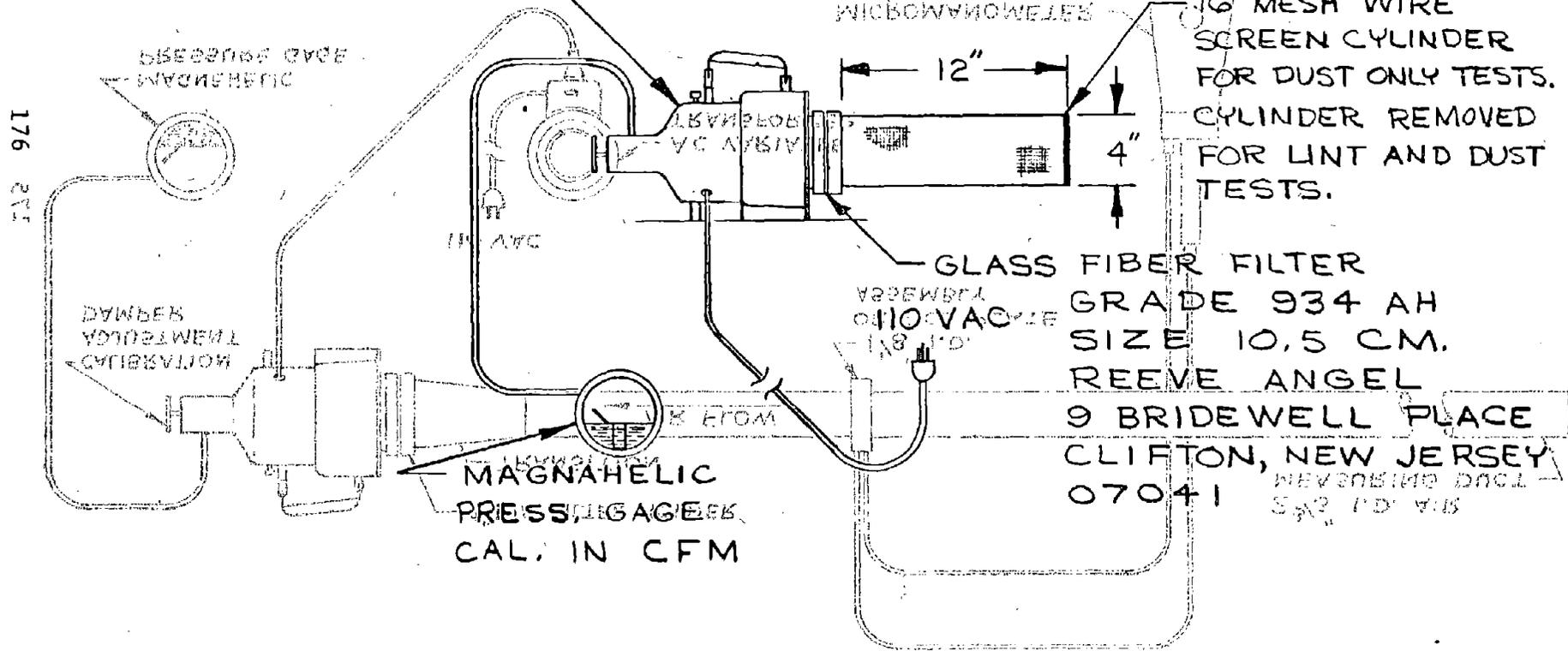
When it is possible to sample on the immediate downstream side of the filter media and the air stream velocity is sufficiently low, the "open-faced" sampler may be used. However, when this location is not accessible, such as when the primary fan is located immediately behind the filter media, it may be necessary to sample in the fan discharge duct. In which case, it will be necessary to sample the air stream isokinetically to obtain a representative sample. First, the velocity in the duct is determined by pitot traverse. Then the inlet velocity in the sampler probe is set to match the velocity of the air stream by appropriate selection of sampling air quantity and probe size.



TEST SET-UP FOR CALIBRATING
 HIGH VOLUME AIR SAMPLERS

HIGH VOLUME AIR SAMPLER
 TEST SET-UP FOR CALIBRATION

UNICO MODEL 550 TURBINE-JET
 HIGH-VOLUME AIR SAMPLER
 UNICO ENVIRONMENTAL INSTRUMENTS, INC.
 150 COVE STREET
 FALL RIVER, MASS. 02720



16 MESH WIRE
 SCREEN CYLINDER
 FOR DUST ONLY TESTS.
 CYLINDER REMOVED
 FOR LINT AND DUST
 TESTS.

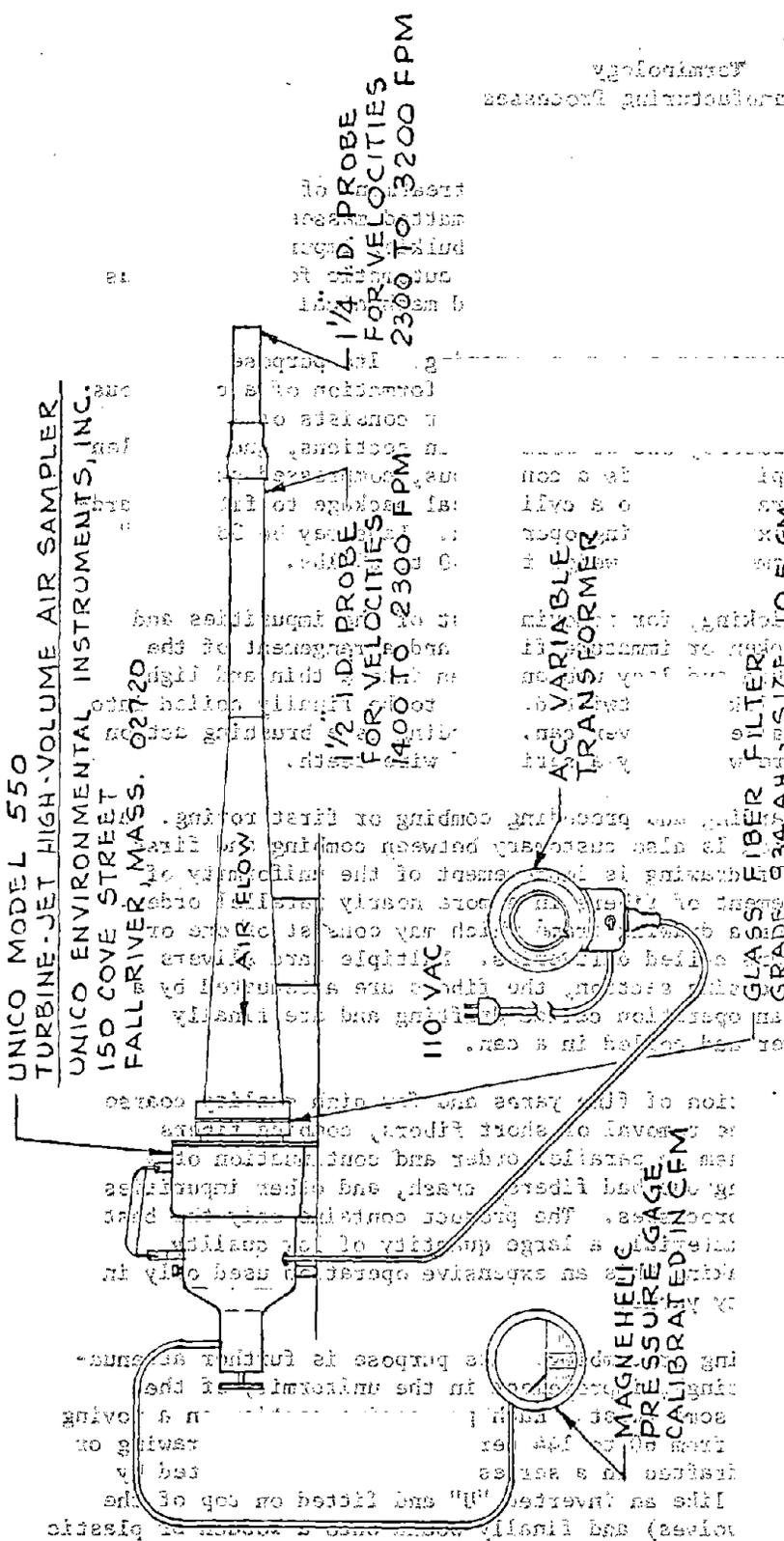
GLASS FIBER FILTER
 GRADE 934 AH
 SIZE 10.5 CM.
 REEVE ANGEL
 9 BRIDEWELL PLACE
 CLIFTON, NEW JERSEY
 07041

MAGNAHELIC
 PRESSURE GAUGE
 CAL. IN CFM

176 PSI

110 VAC

UNICO MODEL 550
 TURBINE-JET HIGH-VOLUME AIR SAMPLER
 UNICO ENVIRONMENTAL INSTRUMENTS, INC.
 150 COVE STREET
 FALL RIVER, MASS. 02720



UNICO ENVIRONMENTAL INSTRUMENTS, INC.
 150 COVE STREET
 FALL RIVER, MASS. 02720

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 FALL RIVER, MASS. 02720

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UNICO ENVIRONMENTAL INSTRUMENTS, INC.
 150 COVE STREET
 FALL RIVER, MASS. 02720

INSTRUMENTATION FOR ISOKINETIC SAMPLING

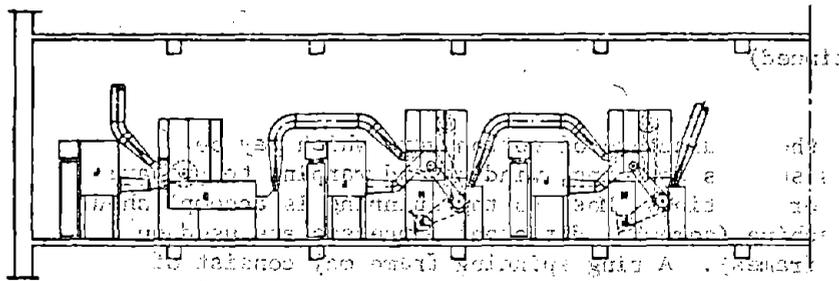
Terminology
Yarn Manufacturing Processes

- Opening:** One of several processes in the preliminary treatment of raw cotton. The purpose is separation of compressed and matted masses of cotton into loose tufts and removal of heavier and bulkier impurities. Typical machines would include bale breaker, automatic feeder, various types of separators or openers, pneumatic and mechanical conveyors.
- Picking:** A cotton processing operation following opening. Its purpose is the further opening and cleaning of the stock and formation of a continuous mat (called a lap) for use on a card. A picker consists of a feed hopper, one or more beaters, one or more screen sections, and the calendar roll section. A picker lap is a continuous, compressed sheet of cotton rolled under pressure into a cylindrical package to fit the carding machines in the next processing operation. Laps may be 38 to 44" wide, 15 to 21" in diameter, and weigh from 40 to 60 lbs.
- Carding:** A process following picking, for removing most of the impurities and some of the short, broken or immature fibers and arrangement of the other fibers into a thin and lacy web and then into a thin and light sliver (in appearance like an untwisted rope) to be finally coiled into a tubular container called a sliver can. Carding is a brushing action in which the fibers are worked by a series of wire teeth.
- Drawing:** A process following carding and preceding combing or first roving. A second drawing operation is also customary between combing and first roving. The purpose of drawing is improvement of the uniformity of the sliver and arrangement of fibers in a more nearly parallel order. This is accomplished on a drawing frame which may consist of one or more processing sections called deliveries. Multiple card slivers are fed into each processing section, the fibers are attenuated by a series of rollers in an operation called drafting and are finally delivered as one sliver and coiled in a can.
- Combing:** A process for the production of fine yarns and for high quality coarse yarns. Its purpose is the removal of short fibers, combing fibers retained and arranging them in parallel order and continuation of a cleaning process by taking out bad fibers, trash, and other impurities not removed in previous processes. The product contains only the best and cleanest of the raw material, a large quantity of low quality components are removed making this an expensive operation used only in production of high quality yarns.
- Roving:** A process following drawing or combing. Its purpose is further attenuation of the fibers (drafting), improvement in the uniformity of the sliver, and insertion of some twist. Each processing section on a roving frame (in number ranging from 60 to 144 per machine) receives drawing or combing sliver which is drafted in a series of rolls, then twisted by means of a flyer (shaped like an inverted "U" and fitted on top of the spindle with which it revolves) and finally wound onto a wooden or plastic bobbin.

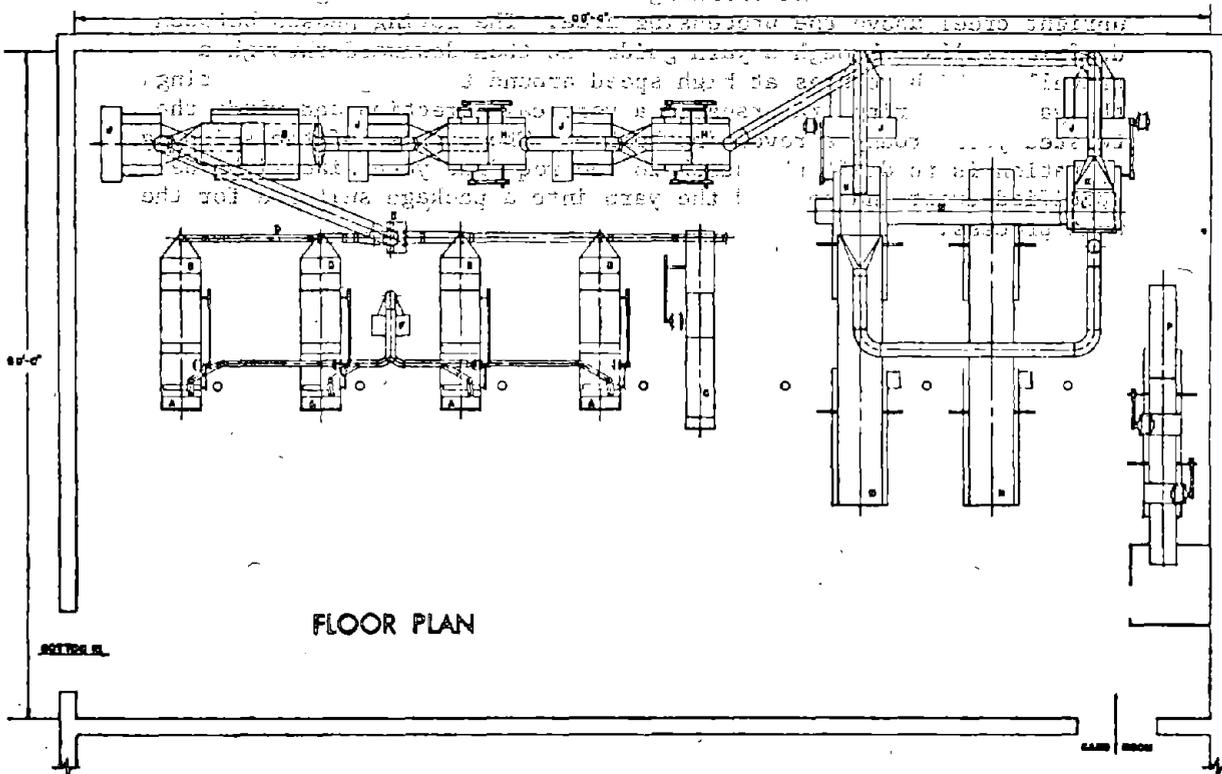
Yarn Machinery Processes (continued)

Spinning: The final process in the manufacture of cotton yarn which may be followed by processes such as spooling, winding and warping to prepare the yarn for weaving or knitting. Most cotton spinning is accomplished on a ring spinning machine (somewhat different processes are used on mules, cap and flyer frames). A ring spinning frame may consist of from 100 to 300 spindles along each side for a total of 200 to 600 spindles per frame. The spinning frame processes roving held in an upright creel above the processing area. The roving passes between drafting rolls, through a yarn guide and then downward through a traveller which rotates at high speed around the ring thus twisting the yarn. The ring traverses in a vertical direction and winds the twisted yarn around a revolving bobbin. The purpose of the spinning operation is to draft the stock to the required yarn size with the specified twist and to wind the yarn into a package suitable for the next process.

TYPICAL MODERN PICKER ROOM FOR CARDED YARNS

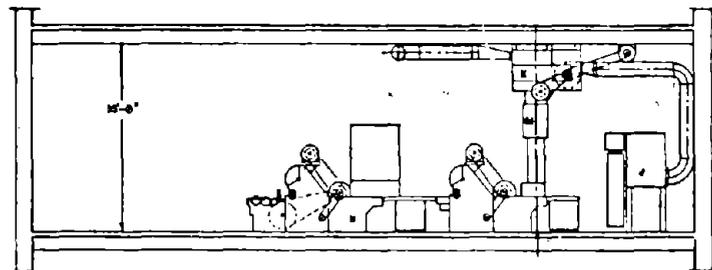


ELEVATION OF
OPENING LINE



FLOOR PLAN

ELEVATION OF
PICKERS WITH
AUTOMATIC CONTROL
FEEDING SYSTEM



- | | |
|---|---|
| <p>A 4 No. 7 Feeders with Motors and Fans.
 B 4 No. 15 Openers.
 C 1 24" F-5S Waste Feeder with 6' 0" Regulator.
 D 1 Pneumatic Conveyor.
 E 1 26" Vertical Eries Magnet with Floor Supports.
 F 1 No. 7 Two-Bag Air Filter.
 G 1 No. 16 Opener with No. 11 Dust and Waste Extractor Feed.</p> | <p>H 2 No. 12 Lattice Openers with No. 11 Dust and Waste Extractor Feed.
 J 5 No. 6 Automatic Air Filters.
 K 2 No. 11 Dust and Waste Extractors.
 L 1 No. 2 Overflow Reserve Box.
 M 1 No. 2 Automatic Control Feeding System.
 N 2 Model 6 F-4 One-Process Pickers with No. 5 Automatic Air Filters.
 P 1 Model 6 Two-Section Waste Machine.</p> |
|---|---|

Basic Terminology - Opening and Picking

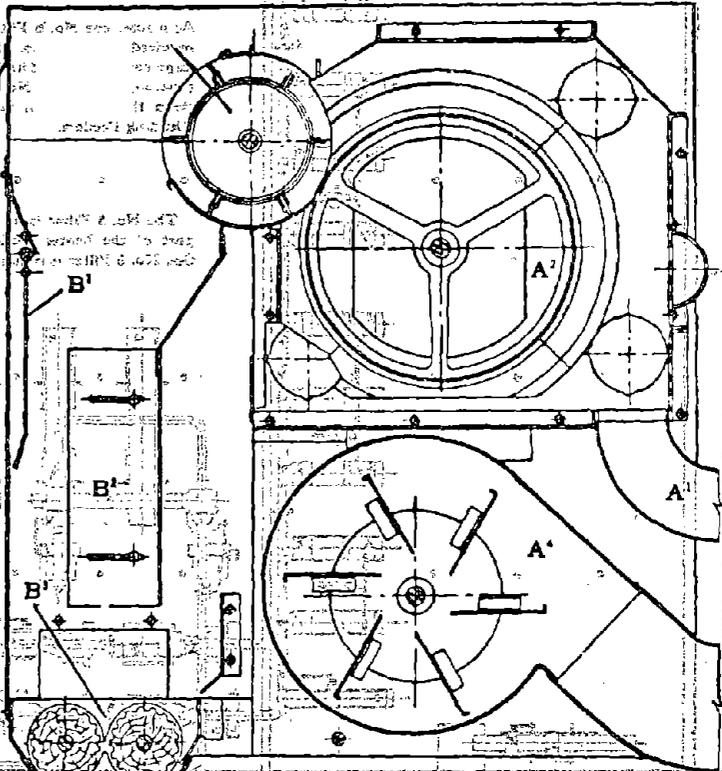
Courtesy of Saco-Lowell

OPENING MACHINERY

NO. 12 LATTICE OPENER AND CLEANER

COMPONENT PARTS OF NO. 12 OPENER

- A. No. 11 Dust and Waste Extractor**
 - 1. Inlet Mouth
 - 2. Condensing Screen
 - 3. Doffer
 - 4. Fan
- B. Reserve Box**
 - 1. Sensitive Rake
 - 2. Adjusting Plate
 - 3. Delivery Rolls
- C. Beater Section**
 - 1. Buckley Beater
 - 2. Beater Pick (192 total)
 - 3. Adjustable Grid Bars (68 total)
 - a. 16 total, 8 each section
 - b. 16 total, 8 each section
 - c. 20 total, 10 each section
 - d. 16 total, 8 each section
 - 4. Access Door
- D. Mote Chambers**
 - 1. Feed End Chamber
 - 2. Delivery End Chamber
 - 3. Cleanout Doors
- E. Trunk Section**
 - 1. Connection for Outlet Mouth
 - 2. Deflector
 - 3. Air Intake Grille and Access Door

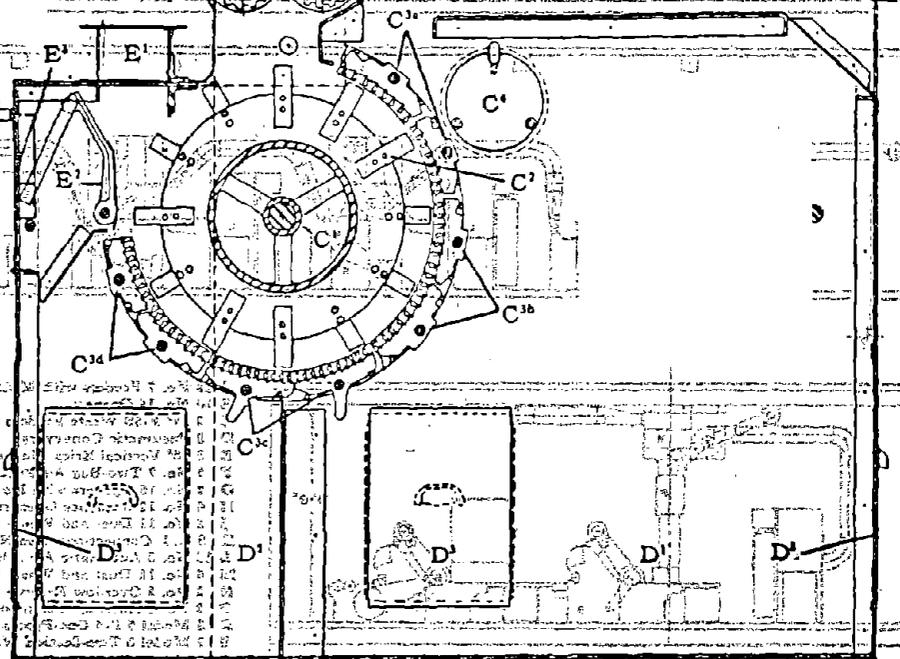


ENGINEERING DATA

Floor Space:
 5'9 1/2" long x 6'6" wide x 9'8" high
 Power Requirements: 7 1/2 H.P.
 Cylinder Speeds:
 450 to 650 R.P.M.
 Production per Hour:
 600 to 1050 lbs. per hr.
 Feed Pulley Diameter: 6" to 10"

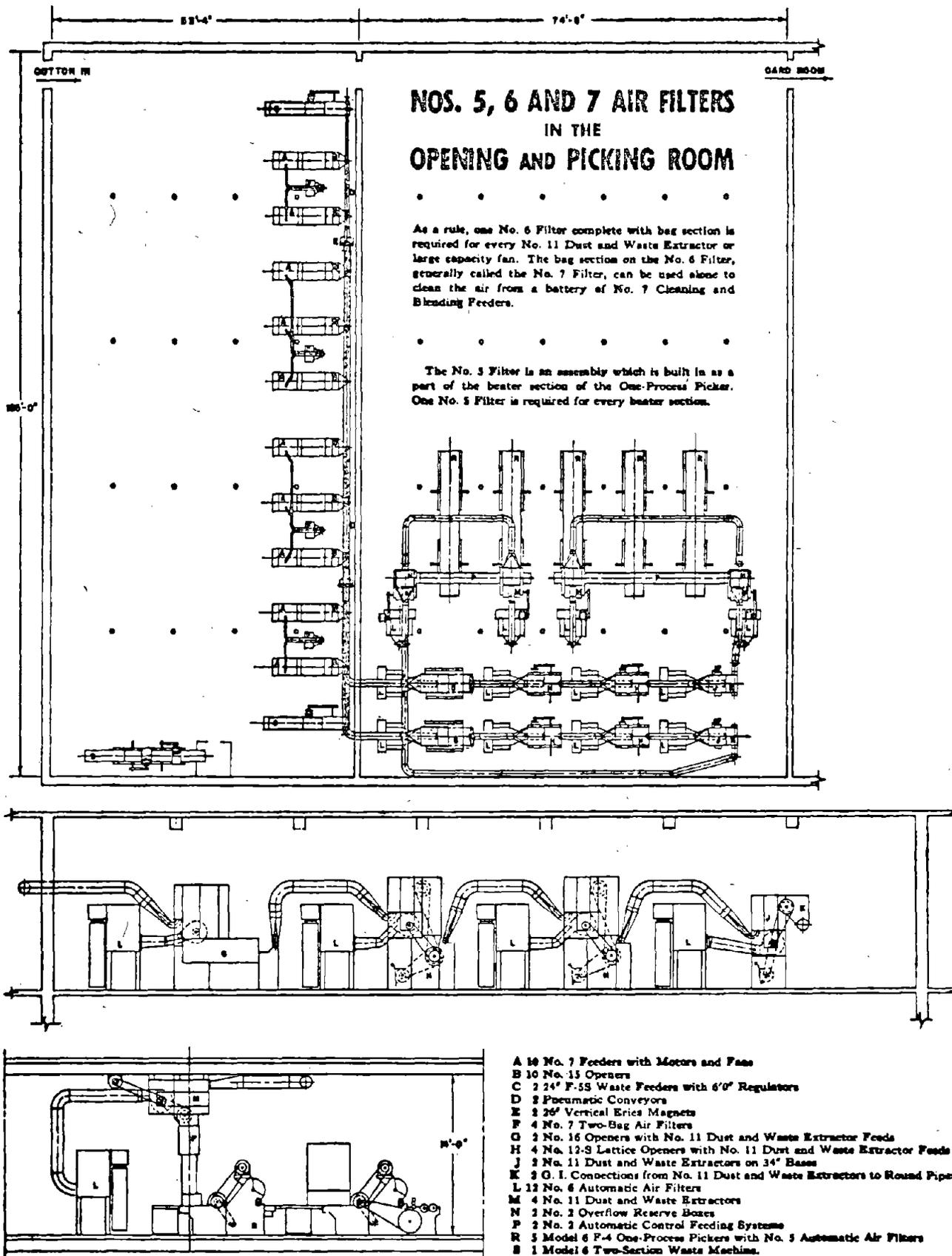
SHIPPING WEIGHTS

Domestic Net Wt. 4300 lbs.
 Domestic Gross Wt. 5300 lbs.
 Foreign Gross Wt. 6100 lbs.
 Cubic Feet 409



Basic Terminology - Opening and Picking

Courtesy of Saco-Lowell



Basic Terminology - Opening and Picking
 Courtesy of Saco-Lowell

NO. 6 AND NO. 7 AIR FILTERS

The Number 6 Air Filter with screen and bag section is a large capacity unit designed to clean the air discharged from high-duty fans such as are used with the No. 11 and No. 12 Condensers. As a rule it will be necessary to use one No. 6 Filter for each No. 11 Condenser Fan

or No. 12 Condenser when a No. 6 Fan is used in the cotton transport system. For cotton transport systems requiring larger fans, the number of filters required will be specified in proportion to the volume of air handled.

OPERATION OF THE NO. 6 AIR FILTER

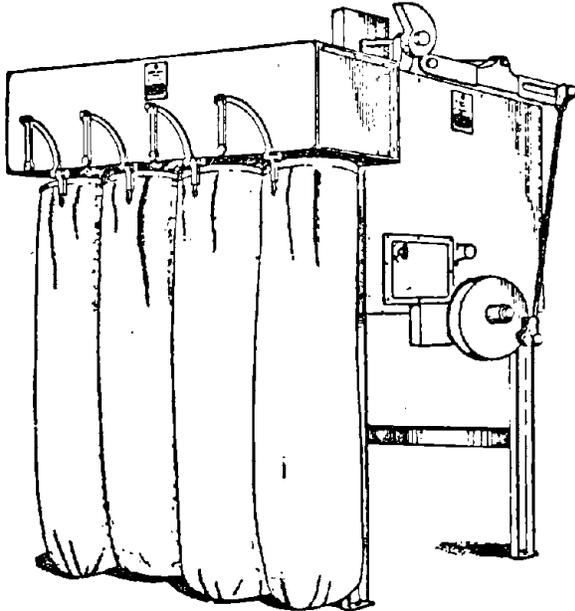


FIG. 1. THE NO. 6 AIR FILTER WITH ATTACHED NO. 7 BAG FILTER UNIT

The No. 6 Air Filter consists of three major assemblies — the housing and its supports, the screen section with its drive and stripping rolls, and the bag filter unit known as the No. 7 Filter.

A perforated steel screen revolves in a set of bearings secured to the housing. Part of the screen section assembly are two steel rolls at the lower front of the housing. Both of these rolls are fluted. One, acting as the stripper, removes the mat of dust and waste from the surface of the screen. The other, acting as a compressor, gives a calendering effect that causes a slight degree of felting to take place and forms the wasty matter on the surface of the screen into a sheet for ready disposal. The No. 7 Filter consists of a main header and the filter bags. Generally, the unit is fastened directly to the discharge side of the No. 6 Air Filter. However, if there is not sufficient room to permit this mounting, then the No. 7 Filter unit can be placed in any convenient location on a specially designed steel support and connected to the discharge of the No. 6 Filter with a conveying pipe.

The air from the fans enters the filter header through the main duct (A), Figure 1, which brings the incoming stream in a direct line straight to the surface of the filter screen (B) without much apparent loss in velocity. The rapidly moving air passes through the perforations of the screen leaving the entrained dust, short linty fibers, and any other impurities on the surface of the screen which filters them from the air stream. In a short time the surface of the screen is covered with a mat composed of the material removed from the air. This mat grows in thickness rapidly. As it increases in thickness, up to a certain point, it acts as a very efficient filtering medium. However, if it attains too much thickness, then a back pressure on the fan moving the air develops, and harmful conditions result.

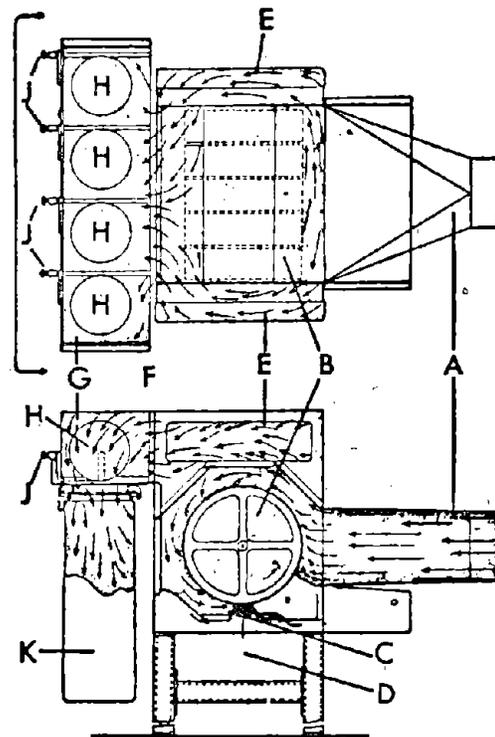


FIG. 2. AIR MOVEMENTS IN THE NO. 6 AIR FILTER

- | | |
|-----------------------------|---------------------|
| A. Main Intake Duct | F. No. 7 Air Filter |
| B. Perforated Filter Screen | G. Header |
| C. Draw Rolls | H. Air Valve |
| D. Mat of Lint and Dust | J. Air Valve Lever |
| E. Dust Flume | K. Filter Bag |

THE NO. 5 AUTOMATIC AIR FILTER

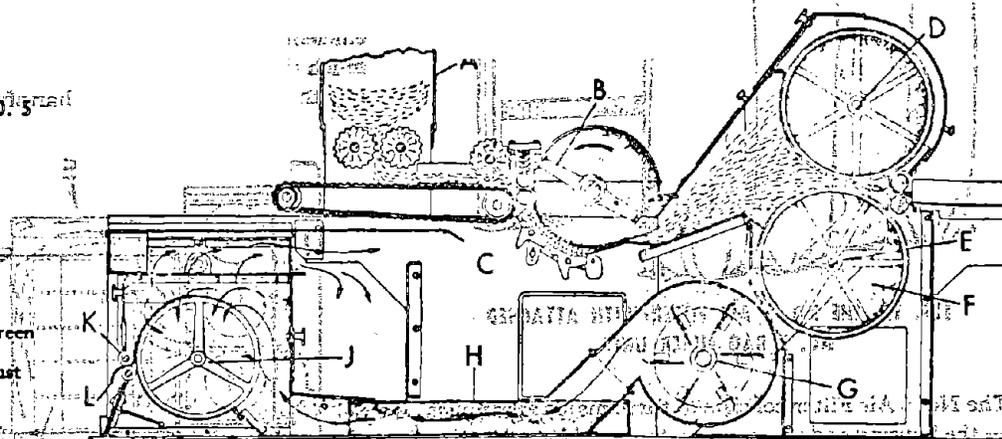
The No. 5 Automatic Air Filter is used as an integral part of One-Process Pickers for the purpose of filtering the air passing through the beater box and fan before it is recirculated in the room.

We do not recommend the use of the No. 5 Automatic Air Filter in the picker room unless the mill has a thoroughly modern opening room with enough cleaning machines, including No. 11 Dust and Waste Extracting Condensers, to remove practically all of the fine dust and pepper trash contained in the cotton. When the cotton in the picker room contains a large amount of fine dust, the No. 5 Automatic Air Filter has the added burden of removing this fine dust with the filter mat, and when the dust load is excessive, it is difficult to obtain the highest efficiency from the pickers. The path of the air through the No. 5 Automatic Air Filter is as follows:

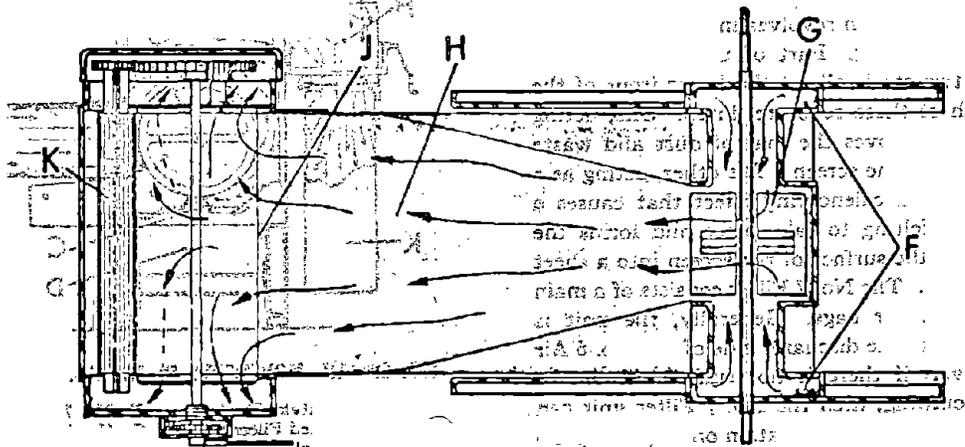
The picker section fan draws air containing the entrained dust and cotton from the beater box. This air, laden with the entrained dust and lint that has passed through the coarse openings of the top and bottom screens, goes down through the dust flue, out of the fan discharge, through the duct, and into the filter housing, where at lowered velocity it comes in contact with the perforated metal filter screen. This filter screen which revolves slowly soon becomes covered with a thin layer of lint and dust. The thickness of this layer is regulated by the speed of the screen. As the screen slowly revolves, the draw rolls take the matted lint and dust from the surface, so that during any operating period there is a cleaning and renewal of the filtering surface and medium. About once every four hours the mat must be removed from underneath the picker.

OPERATION OF THE NO. 5 AUTOMATIC FILTER

- A. Picker Reserve Box
- B. Two Blade Beater
- C. Beater Box
- D. Top Screen
- E. Bottom Screen
- F. Dust Flues
- G. Picker Section Fan
- H. Duct
- J. Perforated Filter Screen
- K. Draw Rolls
- L. Mat of Lint and Dust



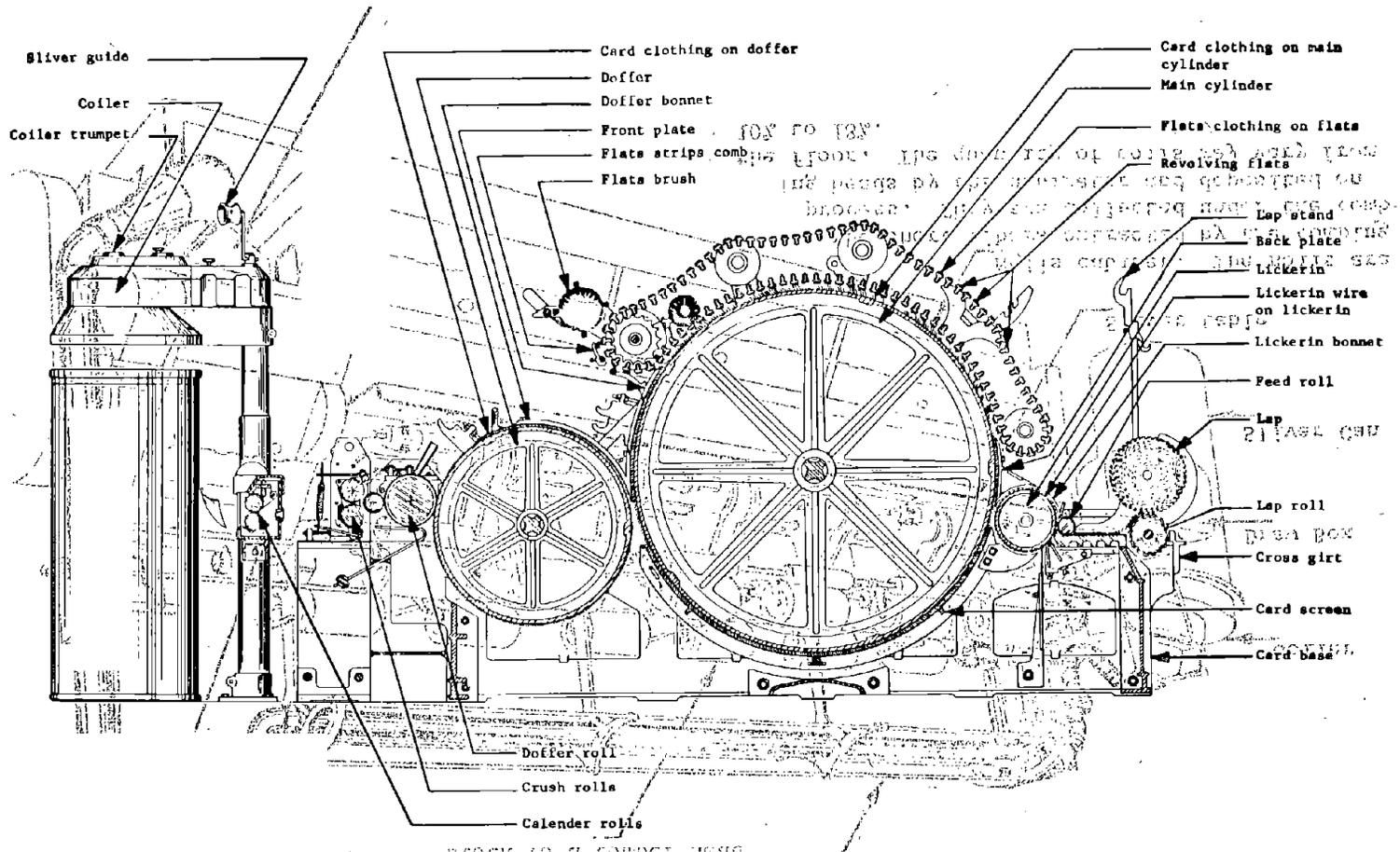
Sectional Elevation of a Standard Beater Section of the Picker equipped with a No. 5 Automatic Filter. Heavy shading indicates dusty and waste-laden air going to the Filter.



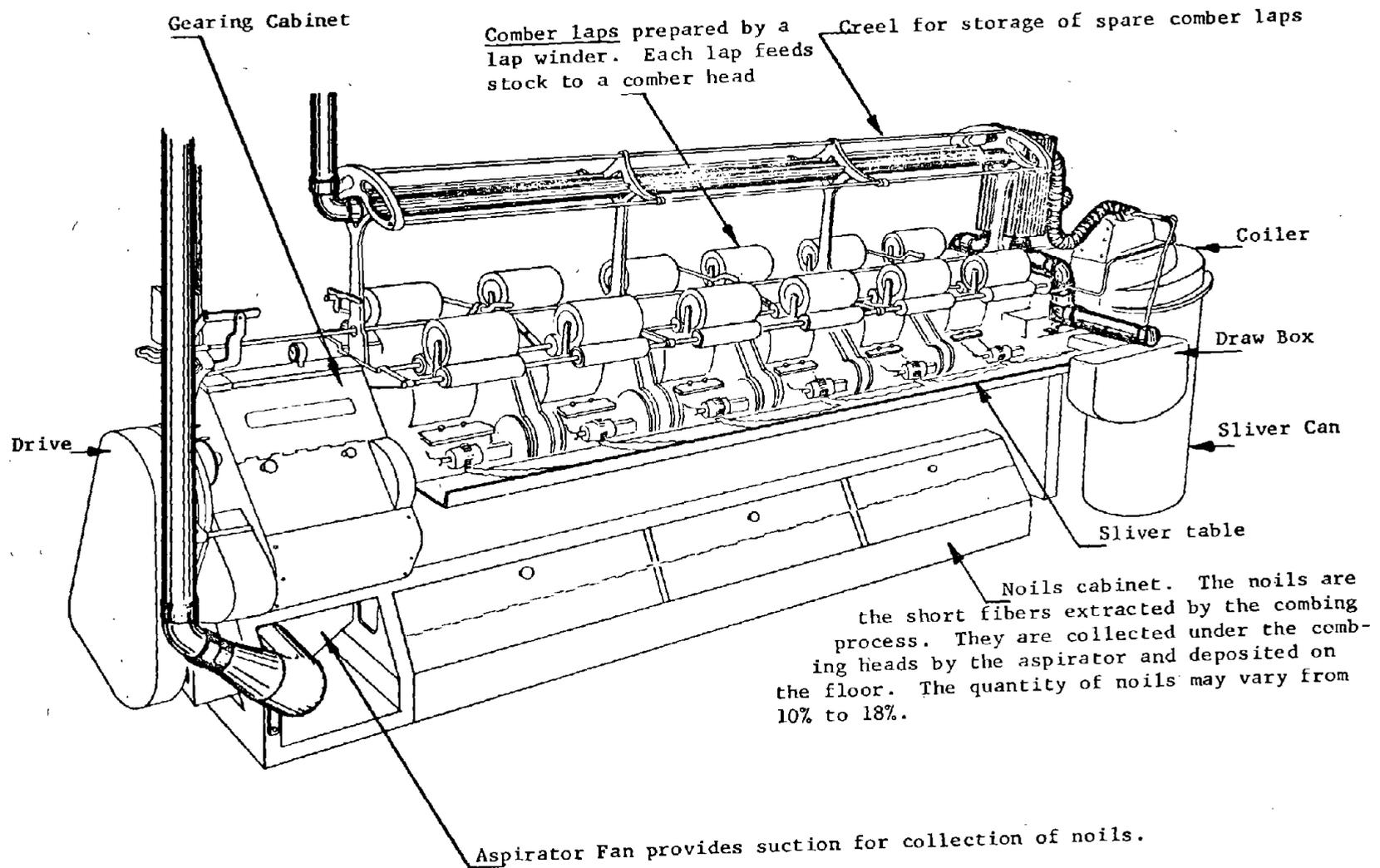
Plan to show circulation of the dusty and waste-laden air from the fan of the No. 5 Air Filter through the perforated filter screen.

Basic Terminology - Opening and Picking
Courtesy of Saco-Lowell

BASIC COMBER TERMINOLOGY



5885



BASIC COMBER TERMINOLOGY

Terminology
Cotton Grades

U. S. Department of Agriculture report on Shirley Analyser tests of 2897 lots of American Upland Cotton from the crops of 1961 and 1962. This also illustrates basic grades of cotton.

Average Percentage

	<u>Picker and Card Waste</u>	<u>Shirley Analyser Nonlint Control</u>
Good Middling	6.3	1.5
Strict Middling	6.4	1.6
Middling	7.1	2.2
Strict Low Middling	8.2	3.1
Low Middling	9.7	4.5
Strict Good Ordinary	11.2	5.8
Good Ordinary	15.0	7.8

Universal Standards - Grade of American Upland Cotton - June 15, 1963

<u>Grade Name</u>	<u>Plus</u>	<u>White</u>	<u>Light Spotted</u>	<u>Spotted</u>	<u>Tinged</u>	<u>Yellow Stained</u>	<u>Light Gray</u>	<u>Gray</u>
Strict Good Middling		SGM						
Good Middling		GM	GM LtSp	GM Sp	GM Tg	GM YS	GM Lt Gray	GM Gray
Strict Middling		SM	SM LtSp	SM Sp	SM Tg	SM YS	SM Lt Gray	SM Gray
Middling Plus Middling	M Plus	M	Mid LtSp	Mid Sp	Mid Tg	Mid YS	Mid Lt Gray	Mid Gray
Strict Low Middling Plus	SLM Plus							
Strict Low Middling		SLM	SLM LtSp	SLM Sp	SLM Tg		SLM Lt Gray	SLM Gray
Low Middling Plus	LM Plus							
Low Middling		LM	LM LtSp	LM Sp	LM Tg			
Strict Good Ordinary Plus	SGO Plus							
Strict Good Ordinary		SGO						
Good Ordinary Plus	GO Plus							
Good Ordinary		GO						
Below Grade								

1974
Abbreviations and Symbols

AC		Air Conditioning				
Avg.	=	Average				
A16M, A16C, etc.	=	Manufacturer's designation of dust capture devices, tubing arrangement, air quantity specifications, etc. for card cleaning equipment				
cfm	=	Cubic feet per minute				
CMC	=	Carolina Machinery Company				
CMG	=	Continental/Moss-Gordin				
Cond.	=	Condenser				
High Vol	=	High Volume (dust sampler)				
HSM 99-72-44	=	Government Contract Number				
in./min.	=	Inches per minute				
LM	=	Low Middling (a grade of cotton)				
LM+	=	Low Middling Plus (a grade of cotton)				
max.	=	Maximum				
mg/m ³	=	Milligrams per cubic meter				
min.	=	Minimum				
n	=	Number of samples				
OD	=	Outside diameter of connecting tubing				
		4½" OD = 4.260" Inside Diameter				
		1.9" OD = 1.754" Inside Diameter				
SIM	=	Strict Low Middling (a grade of cotton)				
\bar{x}	=	Arithmetic mean				
xi	=	Value of each sample				
"wg	=	Inches water gauge				
ΔP	=	Pressure drop, inches water gauge				
σ	=	Standard deviation = $\sqrt{\frac{\sum (xi - \bar{x})^2}{n-1}}$				

4. Title and Subtitle Cotton Dust Controls in Yarn Manufacturing	5. Report Date March 1974
7. Author(s) Harry S. Barr, R. Hovan Hovan Hocutt, and James B. Smith	6.
9. Performing Organization Name and Address Pneumafil Corporation 2516 Wilkinson Boulevard Charlotte, North Carolina 28208	8. Performing Organization Repr. No.
	10. Project/Task/Work Unit No.
12. Sponsoring Organization Name and Address National Institute For Occupational Safety and Health Parklawn Building 5600 Fishers Lane Rockville, Maryland 20852	11. Contract/Grant No. HSM 99-72-44
	13. Type of Report & Period Covered Final
	14.

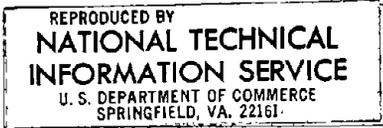
15. Supplementary Notes

16. Abstracts

The purpose of this project was to develop optimum design criteria for cotton processing machinery local exhaust ventilation systems. The two principal areas of investigation were the configuration of exhaust hoods or other devices for capturing dust from cotton processing machinery and methods of filtering the particulate from the exhausted air. Dust capture devices and filters have been developed to maintain the airborne dust concentrations in the work areas below 0.5 milligrams of dust per cubic meter of air as measured by the cotton-dust vertical elutriator. The design specifications were developed and specified for opening, picking, carding, combing and drawing machines of the most common types currently used in manufacturing cotton yarns.

17. Key Words and Document Analysis. 17a. Descriptors
Cotton spun yarns, Dust control, Textile processes, Design criteria, Exhaust systems, Dust filters, Ventilation

17b. Identifiers/Open-Ended Terms



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