DUST CONTROL FOR INDUSTRIAL ARTS SHOPS OF OREGON SECONDARY SCHOOLS

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DUST CONTROL FOR INDUSTRIAL ARTS SHOPS OF OREGON SECONDARY SCHOOLS

CHAPTER I

INTRODUCTION

When we in our daily conversation speak the word "dust" we no doubt create different images in the minds of our listeners. To most people the word has a repugnant connotation. To the housewife, dust denotes a difficult cleaning task. The man in the street sees dust as it is whipped into the air by wind or a passing automobile. The meteorologist sees dust as a blanket in the sky holding back certain harmful radiations: a blanket which also gives us beautiful sunrises and sunsets. For the purpose of this study, dust will be viewed as a nuisance material which must be eliminated from the school shop for reasons of health and efficiency.

Statement of the Problem

Industrial arts, as its name implies, is that area of general education which uses the tools and materials of industry for developmental, exploratory and guidance purposes, and to prepare a general foundation for the experiences many students will need to develop more fully a general or specific background for employment in modern industrial plants. When school shops were used to teach only hand-tool skills the problem of dust in the air was of minor importance; but with the installation of power equipment and high-speed tools the dust concentrations became acute. Power woodworking machinery such as planers, sanders, saws, shapers and lathes each contribute their special type of dust, so that the air soon becomes so loaded with particles that it causes discomfort to the teacher and students who must work in that atmosphere. Long-continued exposure to such dust generates health hazards. As the situation grows worse the teachers, in many instances, have found it necessary to transfer to other departments of teaching or leave the profession. Teacher transfer does not solve the problem but merely exposes other teachers to the intolerable situation and postpones the date of adequate dust control.

Purpose of the Study

The purpose of this study shall be to survey the school shops of Oregon to determine the extent of the problem of dust control and to determine how many shops have inadequate control measures or no dust control.

When the survey has been completed, the next step will be to design a dust collecting system at least reasonably adequate for the small school shop which cannot likely finance a commercial system. Enough design information will be made available in the study to permit the shop teacher to adapt the system to his particular problem.

Definition of the Scope of Study

The survey will be limited to the state of Oregon as it is felt that this will give a representative sampling of school shops with like problems in dust control.

Application of the control system will be confined to the woodworking shop as that is considered to be the greatest producer of nuisance dusts in the secondary school shops. The same fundamentals can be applied to other dry-dust situations that may be peculiar to other types of operation.

Design elements for collection systems will be of elementary nature, thus requiring only a limited understanding and use of technical information to fabricate a system with a minimum of special equipment.

Value of the Study

It is the opinion of the author that there is a need for information on collection systems to be distributed to the industrial arts teachers of the state. Dust, like the weather, is a popular subject for discussion between industrial arts men but few schools have provided the money to install a commercial system which would take care of the situation. This study will attempt to define the extent of need for control measures and suggest a means of attaining that goal in the less wealthy districts.

CHAPTER II

QUESTIONNAIRE STUDY RESULTS

In an effort to establish some data on which a need for the study could be based, a survey was made of woodworking teachers in selected schools of Oregon. The purpose of the study: to determine if there is a recognized dust problem in the woodshops and how the schools are meeting the problem.

In the preliminary selection, 176 schools were picked according to faculty size. No school was selected unless there were at least six teachers on the faculty. It was believed by the author that a small school would have very few power tools to create a dust problem. Several schools with no dust problem, due to lack of machines, would give a misleading assumption as to the extent of the problem.

A preliminary inquiry was made by sending 176 double postcards to selected schools, asking if the instructor would be willing to cooperate in the study by filling out a simple questionnaire. Of the 176, 119 (67.5%) were returned with positive answers. Then 119 questionnaires were sent, including a brief statement of the problem approach, and a self-addressed return envelope. Of the 119 questionnaires sent out, 114 were returned. All questionnaires were returned voluntarily without the need of a follow-up letter. This very high percentage of returns (95.8%) seemed to indicate that the instructors were very interested in the study. Only four teachers indicated they did not desire a copy of the study.

As the questionnaire forms were completed and returned, the information was coded and punched out on Unisort Analysis Cards, Form Y9, thus simplifying the tabulation of the information and cross comparisons between various answers.

Questionnaire Results

Following is the complete text of the questionnaire and the results given in totals, percentage, or both. Some questions are followed by an explanation of the basis for the question, designed to give the reader a better understanding of the reason for the question and how the results were to be evaluated.

QUESTIONNAIRE

DUST CONTROL IN INDUSTRIAL ARTS SHOPS OF OREGON SECONDARY SCHOOLS

GENERAL INFORMATION:

1. "Type of high school in which you teach."

   Basis: To determine if the administrative arrangement of the school affects the dust problem.

Organization	Number	Percentage
Consolidated	60	52.7
Union High	33	29.
City	18	15.8
County Unit	2	1.25
Resident	1	0.75

2. "Class of school."

   Basis: To determine if the size of the school district (population) affects the dust problem.

Class	Number	Percentage
First class	79	69.3
Second class	26	22.8
No answer	9	7.9

3. "Number of students in the student body."

   Basis: To determine if the dust problem increases with an increase in size of the school.

No. Students	Number	Percentage
100-	6	5.26
250-	30	26.3
500-	27	23.7
1000-	31	27.2
1000 plus	16	14.
No answer	4	3.54

4. "Average number of students in your shop classes."

Basis: To determine if the dust problem increases with an increase in shop enrollment.

No. of Students	Number of Schools	Percentage
10-	11	9.65
11-15	27	23.7
16-20	44	38.6
21-25	23	20.2
26 plus	2	1.75
No answer	7	6.10
Average load	17.3	

5. "Which of these dust producing industrial-arts subjects are taught in your program?"

Basis: To determine which subject areas tend to produce the greatest dust problems.

Subject	Number	Percentage
Woodwork	113	99
Plastics	31	27.2
Art Metal	21	18.4
Welding	10	8.77
Foundry	10	8.77

6. "Size of the work space in each dust-producing activity, as above."

   Basis: To determine if the available space in the shop has a bearing on the severity of the dust problem.

   Average size -- 1865 square feet in the shop.

7. "What type of power do you have at your power machines?"

   Basis: To determine the feasability of wiring individual collectors directly to each machine.

Power	Number	Percentage
110 volt single phase	91	80
220 volt single phase	60	52.6
220 volt three phase	60	52.6

SECTION II

1. "Which of these major dust producing machines do you have?"

Basis: To determine which machines in the shop create the greatest dust problem.

Machine	Number	Percentage
Table saw	111	97.4
Jointer	108	94.8
Band saw	106	93
Lathe	104	91.3
Disc sander	91	79.7
Port. belt sander	91	79.7
Planer	62	54.4
Shaper	53	46.5
Belt sander	50	43.8
Buffer	49	43
Welder	39	34.2
Forge	18	15.8
Spindle sander	18	15.8
Radial saw	12	9.5

2. "Which of the above machines creates the most dust?"

Basis: To determine which machines, in the opinion of the instructors, produce the most dust.

Machine	Number	Percentage
Planer	33	28.9
Disc sander	32	28.2
Lathe	15	13.1
Port. belt sander	12	10.5
Table saw	12	10.5
Belt sander	10	8.77
Welder	4	3.5

Radial saw	3	2.63
Jointer	2	1.75
Band saw	2	1.75

3. "Which of the following are cleaned every period?"

Basis: To determine if shops that are cleaned every period have a greater dust problem than those cleaned less often.

Item cleaned	Number	Percentage
Benches	113	99
Machines	100	87.7
Floor	82	71.9
None	1	0.88

4. "Do you require the shop working areas (benches, floor, machines, etc.) to be cleaned?"

Time	Number	Percent
Every period	95	83.4
Once a day	19	16.6
Twice a day	7	6.14

5. "Method of cleaning the shop."

Basis: To determine if the method of periodic cleaning affects the dust problem.

Method	Number	Percent
Brush	112	98
Air hose or blower	24	21
Vacuum	20	17.5
Shop const. portable	8	40

Vacuum		
Central system with drops	5	25
Other systems	7	35

6. "How often is the entire shop given a general cleaning (seldom used tables, tool racks, dead storage, etc.)?"

Basis: To determine if extended time between general cleaning affects the dust problem.

Time	Number	Percent
Once a month	50	43.8
Twice a year	29	25.4
Once a week	27	23.3
Once a year	7	6.14
Four times a year	1	0.875
Every two weeks	1	0.875
Never	1	0.875

7. "Do you use any sweeping compound on the floor?"

Basis: To determine what is being done by the teachers to alleviate the dust problem short of installing a collector.

Answer	Number	Percentage
No	72	63.2
Yes	39	34.2
No answer	3	2.63

SECTION III

1. "How long have you been teaching woodworking?"

Basis: To determine the relationship between sensitivity to dust and the total length of exposure.

Time in years	Number	Percent
1-5	35	30.7
6-10	47	41.2
11-15	14	12.27
16-20	8	7.02
21 plus	9	7.89

Average 9.4 years

2. "How many hours per day do you spend in a dusty atmosphere?"

Basis: To determine the relationship between sensitivity to dust and the amount of exposure per day.

Time in hours	Number	Percent
2 or less	8	7.02
3-4	21	18.4
5-6	48	42.2
7-8	28	24.6
8 plus	6	5.26
No answer	3	2.63

3. "Do you consider the dust to be a serious health problem in your shop?"

Basis: To determine the attitude of the teachers toward dust in its relationship to health.

For the teacher	Number	Percent
Yes	81	71
No	30	26.3
For the student		
Yes	56	49.1
No	58	50.8

4. "How does the dust affect you physically?"

Basis: To determine the beliefs of the teachers concerning the effect of dust on their health.

Affected part	Number	Percent
Nose	80	70.2
Eyes	36	31.5
Lungs	33	28.8
Skin	8	7
Does not bother	29	25.4

5. "To what extent does the dust affect your efficiency as a teacher?"

Basis: To determine the feeling of the teachers concerning their loss of efficiency due to the dust.

Loss	Number	Percent
Some	55	48.25
Not noticeably	49	43
Quite a bit	11	9.65
Seriously impairs	2	1.75

6. "If dust has had an effect on your efficiency, at what time in your career did it become noticeable?"

Basis: To determine if sensitivity to dust was there before teaching was started or if the sensitivity developed on the job.

Year	Number	Percent
1st year	17	14.9
2nd year	10	8.75
2-5	15	13.15
5-10	12	10.5
10-15	4	3.5
15-20	3	2.64
20 plus	2	1.75

7. "Have you ever been incapacitated from the effects of shop dust?"

Basis: To determine the severity of sensitivity to dust by the instructors.

Answer	Number	Percent
Yes	17	14.9
No	94	82.5
No answer	2	1.74

8. "If you have been incapacitated, how many times?"

Average 2.62 times

9. "Is any fiberglass material sanded in your shop?"

Basis: To determine if the fine glass dust has caused special health problems.

Answer	Number	Percent
Yes	32	28
No	78	68.5

10. "Does the dust situation in the shop have any bearing on your intention to remain indefinitely in your present field?"

Basis: To determine if the teachers consider the dust problem a nuisance or a severe health problem.

Answer	Number	Percent
Yes	44	38.6
No	67	58.75
Undecided	1	0.87

SECTION IV

1. "Do you need a dust control system in your shop?"

Answer	Number	Percent
Yes	106	93
No	6	5.25

2. "Do you believe that a dust collecting system which would remove only the airborne dust from the machines would be practical in a woodworking shop?"

Basis: To determine if the instructors are more interested in removal of the dust as a health measure or removal of all machine waste as a convenience measure.

Answer	Number	Percent
Yes	67	58.75
No	42	36.8
No answer	5	4.5

3. "What type of collecting system do you prefer?"

Answer	Number	Percent
Central	67	58.7
Individual	42	36.8
No answer	5	4.38

4. "If you do not have a dust collecting system, how much do you estimate your school could afford to spend for a collector?"

Amount	Number	Percent
$100-	7	7.3
300-	22	22.9
500-	22	22.9
1000-	20	20.8
1500-	4	4.17
2000-	5	5.2
2000 plus	7	7.3
No answer	9	9.37

5. "Would the fact that an outside exhaust removes heat from the building influence your selection of a collector?"

Answer	Number	Percent
Yes	48	42.23
No	62	54.5
No answer	4	3.5

6. "Have you had any fires or explosions in the shop that were attributed to dust?"

Answer	Number	Percent
Yes	3	2.4
No	111	97.6

SECTION V

1. "Do you have a collecting system?"

Answer	Number	Percent
Yes	18	15.8
No	90	79
No answer	6	5.2

2. "If you have a collecting system, of what type is it?"

Answer	Number	Percent
Central	11	61.2
Individual	4	22.2
Area Machine	3	16.6

3. "What type of separator is used to separate the dust from the air?"

Type	Number	Percent
Low pressure cyclone	2	11.1
High pressure cyclone	5	27.8
Cloth Filter	3	16.6
Settling chamber	1	5.5

Rotoclone	2	11.1
No separator	5	27.8

4. "Is the air from the separator

	Number	Percent
Returned to the room?"	4	22.2
Exhausted outside?"	14	77.8

5. "Number of machines exhausted."

   Average 5

6. "Estimated cost of the collector system."

   Average (13 units reported) $1,293

   Range $60 to $5000

7. "Indicate which three items in your opinion are the most important in a collecting system, considering your present needs and financial status. Please list these factors in order of importance.

Low cost	1- 19 2- 21 3- 11
Low maintenance	1- 0 2- 15 3- 14
Effective removal	1- 57 2- 12 3- 14
Removes dust and shavings	1- 25 2- 18 3- 8
Is convenient to use	1- 13 2- 19 3- 19

Can be made in the shop	1- 5
	2- 4
	3- 5
Is portable	1- 0
	2- 1
	3- 1

<u>Some Comparisons Between Answers to Specific Questions</u>

To determine some pertinent data not asked for specifically in the questionnaire, answers from selected questions were compared.

Table 1 indicates that the class loads in the various administrative units are comparatively even, with the greatest percentage concentrated in the 16 to 20 students-per-class group. Of the three largest, the Union High school group has the most favorable class load with 53.6% of the classes in the 15 or less category. The city schools with 27.8% of the students in the 21 plus class-load-group has the heaviest overall class load.

In Table 2 it will be noticed that the city schools, with 15.8% of the schools reported, have 33.3% collector-equipped schools. Whereas they have the heaviest class loads, they also appear to be doing the most to control dust. The Union High school with a low class load also has the lowest percentage of collector-equipped schools (9.1%). The larger schools, according

TABLE 1

A COMPARISON OF CLASS LOADS IN SCHOOLS,*
BASED ON ADMINISTRATIVE ARRANGEMENT

Class Size	City		U.H.		Consol.		County		Resident	
	No.	%	No.	%	No.	%	No.	%	No.	%
10 minus	3	16.65	5	15.6	5	9.25	0		1	100
11 to 15	2	10.2	9	28	15	27.8	0		0	
16 to 20	8	44.4	11	34.4	25	46.4	2	100	0	
21 to 25	5	27.8	5	15.6	9	16.7	0		0	
26 plus	0		2	6.25	0		0		0	

*Seven schools not reported

TABLE 2a

A COMPARISON BETWEEN SCHOOLS ACCORDING TO ADMINISTRATIVE ARRANGEMENT, CLASS, AND SIZE OF STUDENT BODY TO DETERMINE THE EFFECTIVENESS OF DUST CONTROL EQUIPMENT

School Category	A	B	C	D	E	F	G
		%		%	%		%
Consolidated	60	53	7	12	39	39	65
Union High	33	29	3	9	17	25	76
City	18	16	6	33	32	14	78
County Unit	2	1.75	1	50	6	2	100
Resident	1	1	1	100	6	1	100
First class	79	69	17	22	94	64	81
Second class	26	23	1	4	6	16	62
Student body enrollment							
100-	6	5	0	0	0	1	17
250-	30	26	2	7	11	20	67
500-	27	24	6	22	33	26	96
1000-	31	27	3	10	17	20	64
1000 plus	16	14	7	44	39	10	62

Legend for above table:

A- Total schools reported.
B- Percentage of all schools reported.
C- Schools that have dust collectors.
D- Percentage that have collectors.
E- Percentage of all collectors reported.
F- Schools with a dust problem for teachers.
G- Percentage of schools with a dust problem for teachers.

to student body or school population, had the largest percentage of collectors. The city schools also had 33.3% of all collectors reported.

According to school district population (1st and 2nd class districts), the first class districts accounted for 69.3% of the total schools reported and contained a total of 94.5% of all collectors.

According to size of the student body, the collectors appear to be mainly concentrated in the 250-500 student schools (33.3%) and the 1000 plus size (38.9%).

A teacher who finds dust a health hazard would find the best chances for good working conditions in a city school (33.3% collector equipped) in a first-class district (21.5% collectors) with a student body of 1000 plus population (43.7% collector equipped).

The large schools (1000 plus) represented 14.1% of the students reported but had 38.9% of the collectors reported. The next best percentage was reported by schools in the 250-500 pupil size, in which schools comprising 23.7% of the total had 33.3% of the collectors.

Comparisons were made to find out, if possible, why some teachers were affected by the dust more than others and whether control measures are effective in alleviating the distress. As the greatest interest of this study concerns those teachers who are affected adversely by shop dust, the following checks were made.

1. Of those who are affected by dust, how many have collectors?

   Of the 68 persons affected, none seriously, 9 had collectors. Of the 11 who were affected "quite a bit," two had collectors and of the 55 men who were affected to "some" extent, 7 had collectors.

2. Of those affected, how many use sweeping compound?

   Here it was found that 100% of those seriously affected by dust did not use the compound. Of those affected quite a bit, 78% used no compound and of those affected somewhat, 57% did not use compound. It would appear from these figures that those individuals affected by the dust could alleviate some of their trouble by use of a reliable dust laying material.

3. To determine if there was a relationship between the length of time one was exposed to dust and the severity of the effect of the dust, a check was made to determine how long those who had been incapacitated spent in the dust each day.

   Of those incapacitated, the greatest number

(31%) spent 6 hours in the shop.

Of those not incapacitated by affected "some," 37% spent 6 hours in the shop.

Of those not incapacitated by affected "quite a bit", the majority, or 55.6%, spent 8 hours in the shop.

Of those not incapacitated but affected "seriously" by the dust, 100% spent 6 hours in the shop.

From the above figures it would appear there is little proof that length of exposure to dust is the main factor in determining sensitivity to dust. All the groups indicated that 6 hours exposure was the most common except for the "quite a bit" group which had 8 hours.

4. To determine if the sensitivity was developed on the job or was in effect before shop exposure, a check was made of those who had been incapacitated to determine when they first became sick. At the same time a comparison was made with those who had not been incapacitated to see when they had been affected. It was believed that such a study would indicate the percentage of those people who came to the work with a sensitivity.

TABLE 3a

WHEN THOSE NOT INCAPACITATED WERE FIRST AFFECTED

Year	1st	2nd	2-5	5-10	10-15	15-20	20 plus
	36.4%	13.6%	0%	22.7%	13.6%	6.8%	0%

TABLE 3b

WHEN THOSE INCAPACITATED WERE FIRST SICK

Year	1st	2nd	2-5	5-10	10-15	15-20	20 plus
	0%	46%	0%	38.4%	15.4%	0%	0%

From these figures one can see that the greatest percentages are at the beginning of the teaching experience. This would seem to indicate that either the person came on the job with a latent sensitivity or encountered severe dust conditions which overcame normal resistance in a short time. It is significant that of those who were incapacitated, 70.6% said the dust had a bearing on whether they stayed in the woodworking field or not. Of those not yet incapacitated, 34.4% said the dust had a significant influence on their desire to stay in the field.

5. To find out if the length of time of exposure to dust per day or some other factor was influencing the teacher's decision to remain in the woodworking field, a comparison was made between intention to

remain in the field, length of time in the classroom and size of the classes.

TABLE 4

FACTORS AFFECTING DECISION
TO REMAIN IN THE WOODWORKING FIELD

Time in dust hours	Contemplating change %	Class size	Contemplating change %
2 or less	27.2	10 and less	27.2
4	33.3	11-15	44.5
6	35.2	16-20	36.4
8	46.5	20-25	48
8 plus	33.3	25 plus	50

The desire to remain in the field appears to decrease as either time in the shop or size of the classes increases. They are probably several conclusions that may be drawn from the above table. (1) That the amount of dust in the shop is a direct cause of dissatisfaction. (2) That heavy class loads are a direct cause of dissatisfaction. (3) That heavy class loads may cause a greater dust problem which in turn influences conclusion (1).

In another investigation it was found that 33.2% of those who had been incapacitated have been sanding fiberglass material in the shop. This high percentage indicates a possible area for further research due to the special dangers associated with fiberglass sanding dust.

<u>Teacher Specifications for a Collector System</u>

Based on answers given in the questionnaire, the average cost of presently installed collectors is $1,293 per unit. Those presently without collectors feel that their schools could spend an average of $640 per unit to install controls of some type. This seems to indicate that the smaller schools are interested in doing something about the dust situation but feel that they cannot afford the commonly accepted type of system due to the high cost.

When asked which items they consider to be most important in the design of a collecting system, they listed the following as their first choice:

1. Effective removal of waste.
2. Removes dust and shavings.
3. Low in cost.

This would indicate that the men are primarily interested in getting a system that does a good job despite the cost. The fact that cost ranked third out of a possible seven choices indicated that it was a significant factor in the choice.

When asked for their second choice as to what was the most important, cost was the first choice followed by convenience in use, and removal of dust and shavings, in that order. This would also indicate that cost is a very important factor in most of the schools.

CHAPTER III

THE EFFECTS AND CHARACTERISTICS OF SHOP DUST

The fact that dust in the shop has been a source of trouble is well known to most industrial arts instructors. The extent to which dust affects the health and safety of industrial arts personnel has been estimated and deduced by personal observations, but little information has been made available which can be supported by medical tests. On the other hand, the health and safety of shop personnel in the factories and industrial shops has been recognized as an important production variable and much has been done to eliminate dust as a hazard to that production. Mr. T. J. Barry, Consultant for Industrial Dust Control, Pittsburgh, Pa., says: (5, p. 52)

> A dust atmosphere in a plant working area is a nuisance. It either produces a health hazard, an explosion hazard, affects the product, results in excessive wear on the equipment, or causes the workers to do anything but their best work.

Industry therefore realizes that to get the most return for money expended they must make the working situation as pleasant and as safe as possible for the men who are required to do the work. The amount of money spent on improvements along this line is hardly questioned if the results are for the overall benefit.

> The management of our progressive companies is becoming more and more concerned with not only the physical welfare of their employees, but also with their plant and community relationships. They will spend any required amount of money to eliminate a health or explosion hazard when they know that such a hazard exists, and they will do the same when shown that by the elimination of the so-called nuisance dust they can reduce spoilage of products, reduce wear of equipment, and improve the employee-employer relationship. (5, p. 52)

Probably the greatest concern of the school shop teacher in relation to the dust problem is how <u>his</u> health will be affected by prolonged exposure to these airborne particles.

As stated at the heading of this chapter, dust is a nuisance and probably this is its chief characteristic in the school shop. It gets in the eyes, is inhaled into the nose and lungs, irritates the nasal passages, causes violent sneezing, and covers the clothing with unsightly dirt. As disagreeable as these acts are, they are insignificant in relation to the health dangers that may arise from continued exposure to such conditions. Coca, Walzer and Thommen (7, p. 412) state:

> Woods are not infrequent causes of atopic symptoms in occupations involving their handling and sawing. Sawdust may be conducive to the production of asthma, not only because of the irritation to the bronchi produced by the constant inhalation

> but also because of its action as a specific atopen. Among the woods which have been recorded as excitants are mahogany, birch, cedar, tamarack, pine, and others.

Dr. C. O. Sappington, in Essentials of Industrial Health (12, p. 185-186), also recognizes the inherent dangers of long exposure to wood dust. He writes:

> Organic dusts contain carbon and are largely derived from substances of animal and plant origin. Examples of these are textile dusts, flour, sugar, wood, leather and feathers. Organic dusts may irritate the skin, causing an occupational dermatitis, or may irritate the conjunctiva. Many, if not most, organic dusts may cause an allergic reaction in some persons. When present in a very large quantity, any organic dust may cause irritation of the upper air passages. Some woods may cause skin irritation, notably Brazil wood, satinwood, teak, some mahoganies, cocobolo, and California redwood.

The teacher or pupil who reacts to excessive dust by sneezing or other manifestations of hay fever has probably become allergic to the material in the air. The nose mucus lining, through constant bombardment by dust particles, becomes sensitive to further attacks and reacts to prevent further damage and irritation. The 1957 Guide for the Heating, Ventilating and Air Conditioning Industry (4, p. 145) explains the conditions as follows:

> These substances are known as allergens and consist of air-borne irritants such as dusts, molds, feathers, pollens, animal

> dander and others; of food protein, such as milk, wheat, eggs, etc., or of simple chemicals brought in contact with the skin. They may enter the body by various routes of which inhalation is the most common type.
>
> The offending substance reacts with the sensitized cells of the mucous membranes or skin. During this reactions, histamine or a histamine-like substance is released and causes (a) increased capillary permeability, (b) secretion of mucus and (c) muscular contraction. In the eyes and nose this produces itching, redness and lacrimation of rhinorrea; in short, the symptoms of hay-fever. In the lungs it causes in addition to the secretory response, a contraction of the smooth muscles of the bronchi resulting in bronchial asthma.
>
> It is assumed that the presence of frequent allergic bronchial constrictions renders the smooth muscles of the bronchi so sensitive to various non-specific stimuli that the threshold of their response to such irritation is considerably lower than that of a non-allergic individual.

Based on the above information, it would appear that dust would cause an uncomfortable condition in the nasal passages but probably no fatal illness. The asthmatic condition, while not usually a fatal illness, is still disabling enough to require frequent absence from work or permanent change of teaching field.

What then, the teacher asks, is the effect on the lungs of breathing in great quantities of wood dust all day? Am I not liable to develop diseases of the lungs from the constant irritation?

From information available it has been found that there is less danger of disease in the lungs than would appear likely and that the greatest threat is to the nasal passages. Dr. Rutherford T. Johnstone (10, p. 386) explains the action of dust in the lungs in this manner:

> It should be obvious that for any dust to be inhaled it must be floating in the atmosphere. To be suspended it must be almost invisible, extremely small, and light weight.
>
> That only negligible amounts of dust ever reach the lungs is a fact not realized by the layman and frequently forgotten by the physician. The efficient barrier which nature has devised enables man to go through life without incurring harms, although he may be constantly living in a dusty atmosphere. The first obstruction encountered by dust is the fine hair at the port of entry, the nose. These hairs filter out the larger particles of dust. Those smaller particles which pass this first barrier are then met by the mucus of the upper respiratory tract where they are engulfed to be blown or coughed out. In the trachea and bronchi the ciliated epithelium are in constant upward motion and propel fine dust particles to the point where they are coughed out or expectorated in the sputum. Beyond this barrier, the phagocytic cells gather in dust particles and transport them to the hilar nodes to be destroyed.

The fact that most of the dust is retained in the nasal passages is further substantiated by the following statement (13, p. 111A):

> More recent studies have shown that although particles above 5 microns are completely retained, (in the body) retention occurs in the nasal passages and upper respiratory tract, and therefore particles of this size do not penetrate

> to the alveoli. Retention in the upper respiratory tract decreases with decrease in particle size and there is virtually no retention of particles less than 1 micron.

For purposes of filter selection, the average size of wood dust particles has been established as up to 90 microns (17, p. 262). This clearly places the dust in the size group that would be retained in the nasal and upper respiratory tract. But what of the few extremely small particles that do get by the filters and lodge in the lungs? What is their effect on the body? Dr. Rutherford T. Johnstone (10, p. 386) again makes a clarification of this point by the following explanation: "Organic dusts are chemically inert. If a portion of any one of these inert dusts reaches the pulmonary tissues, no chemical reaction occurs."

This viewpoint of non-reaction with lung tissue is also expressed by Dr. C. O. Sappington (12, p. 186), who writes:

> Organic dusts do not cause pneumoconiosis or pulmonary fibrosis of a specific disabling nature. The particles of many types of organic dusts are not of the size or shape to permit them to penetrate to the lung tissue and those that do gain entrance into the body are absorbed.

Study of Shop Dust

Following the survey of Oregon shop teachers, a study of actual conditions as found in a school shop was conducted. The purpose of this experiment was to determine as closely as possible just how much dust is produced and the rate of dust settlement following certain woodworking activities.

This study started as a measurement of the dust produced in a typical shop during a normal work period; but it was soon discovered that conditions within the shop varied so much from day to day and hour to hour that a more accurate method of determination was needed. To gather information concerning the dust situation, a controlled dust-producing activity was carried on and the products of the experiment were analyzed and compared to other collected samples.

One of the methods used to gather information for this study was as follows: As each machine was operated to add its dust to the general shop atmosphere, a test-sample plate was placed at the machine, in the area of the head of the operator, to determine how much dust is picked up by each person as he goes about his work at the machine. Other tests similar to this were constructed to point up information concerning certain characteristics of the dust problem. Still other tests of a similar nature were conducted to measure rate of fallout, distance of dust drift, amounts of dust inhaled, etc.

Survey of Machine Dust

The purpose of this series of tests was to determine the relative amounts and specific character of dust particles produced by the various shop activities and to see how long dust particles remain in the air.

Information for this experiment was obtained from a series of six tests as listed below. Areas for testing were picked according to the amount of student activity in the area. Six areas were designated as typical work stations where a student would be most likely to spend a considerable part of his class time. The tests were made in the woodworking shop of the McLoughlin High school, Milton-Freewater, Oregon.

General areas:

No. 1. Bandsaw, planer area.
No. 2. Belt sander area.
Nos. 3, 4 and 5. Workbench areas.
No. 6. Table saw area.

At each station there was placed a piece of clean window glass 12" square, on which the dust sample would be collected. This sampler was set up 60" from the floor to sample air conditions head-high to the average student. Each dust sample was then removed from the glass with a razor blade and weighed on a sensitive balance capable of weighing by milligrams. No effort was made to check the water content of the samples as the weather was constant throughout the tests.

To get controlled dust conditions, a specified amount of dust-producing work was done for each test and the results compared with the dust captured from a previous experiment.

The work done to produce the dust during the conduct of the tests is here listed to give an understanding of the amount of dust generated. The amount of dust captured becomes more meaningful when the amount originally released in understood. (See Table 5)

Conduct of the Tests

The tests were conducted the following manner:

1. Tests were started after the shop had been out of use for three days. This allowed the normal dust concentration to settle out of the air, so that the results were all from an equal base.
2. Test No. 1. Planer, band saw and sander were run starting at 8:30 a.m. The dust was allowed to settle on the collecting plates all day and was weighed that evening. None of the machines had dust collecting hoods.
3. Test No. 2. Planer, band saw, jointer, lathe and

TABLE 5

MACHINE OPERATIONS

Activity	Material Machines	Size	Cutting Action	Time
Planer 12" Delta	Mahogany	1x6x72	12 cuts, 1/16"	20 min.
Lathe	Mahogany	6½x6½x2	Turned and sanded bowl	40 min.
Sander, 6" belt	Fir	1x16x32	Sanded top and 4 edges	25 min.
Table saw 10"	Mahogany	1x3x120	12 cuts, 120"	15 min.
Band saw	Fir	6x6x12	12 cuts through 6x6	18 min.
Jointer 6"	Mahogany	1x6x36	30 cuts on edge 1" wide	8 min.
Cleaning	Dust on Bench, Floor, Machines		Cleaned twice, 1 hr. apart	10 min. each cleaning

table saw were running starting at 8:30 a.m. the following day. Dust was again allowed to settle during the day and was weighed at night.

4. Test No. 3. Dust which had accumulated on the machines, floor and benches was cleaned off. Cleaning started at 8:30 a.m. and 9:30 a.m. and continued for 10 minutes each. Cleaning tools used were 24" hair bristle push broom for the floor and bench brush

for benches and machines. Brushing and sweeping were done quite vigorously as would normally be done by students in a hurry to clean up. Dust was allowed to settle throughout that day and was weighed at 5:00 p.m. that afternoon.

5. Test No. 4. Dust remaining after the cleaning test was allowed to settle on the plates from 5:00 p.m. until 8:00 a.m. the following morning to check overnight fallout.

6. Test No. 5. Dust was allowed to settle on the plates from 8:00 a.m. until 8:00 a.m. 48 hours later. As there was no activity in the shop during this period the deposit would correspond to settlement from Saturday a.m. to Monday a.m. This weekend test was to determine if there was still a considerable amount of fine dust in the air which would require a long period of time to settle out.

Samples Taken at Operator Face Level

As each machine was operated, the amount of dust generated at face level was measured by use of a sampler set as close to the face of the operator as possible. This sampler was set on edge at an angle of 60 degrees to prevent the retention of large chips and slivers that

TABLE 7

RESULTS OF DUST PRODUCING TESTS
(weights in milligrams)

Machines used	Planer Band saw Sander	Planer Band saw Jointer Lathe Table saw	Floor, Benches, Machines (cleaned)	Overnight settling	Weekend settling
Test No.	1	2	3	4	5
Station I	62	165	15	8	3
Station II	326	136	27	9	4
Station III	42	37	12	7	2
Station IV	35	23	14	7	Trace
Station V	40	47	20	5	Trace
Station VI	8	26	16	8	Trace
Average	85.5	72.3	17.3	7.3	1.8

are of little importance to the study and which would give a false weight reading. Glass samplers were 12" square. The sampler was allowed to remain in place 10 minutes after the machine test was completed to give air-borne dust time to settle.

SAMPLE RESULTS

Planer	6 mg.	Small amount thrown back into the face of the operator. Most dust goes out the rear of the machine.
Lathe	370 mg.	Much large material. Very heavy concentration of sanding dust. Students should wear a protective mask while using this machine.
Sander (Belt)	64 mg.	Six inch belt sander. Top and bottom sides of the belt used. Mostly very fine material thrown up by this machine as the heavier particles are thrown horizontally. Throws much dust into the air that does not stay in the vicinity but circulates in the shop.
Table saw	23 mg.	Considerable amount of dust, much of it also quite large and not bothersome to the nose. The operator standing directly in line with the saw gets a high concentration of dust. This machine caused more discomfort to the eyes than any other machine due to the force of the dust and the constant air stream.
Band saw	12 mg.	Dust situation not bothersome to the operator. Most of the dust circulated below face level which was not picked up on the plate.
Jointer	4 mg.	Very small amount of dust generated.

<u>Test to Determine Rate of Settling During the Day</u>

While Test No. 3 (cleaning benches and machines) was being run, 6 plates of glass were laid out on a workbench at station V. This station was selected because it was centrally located in the student work area.

The problem was to determine how rapidly dust in the shop would settle out of the air. To figure the rate of settlement, the plates were picked up at predetermined times during the day and the accumulated dust was weighed.

Brushing strokes used to clean the benches close to the sampling bench were made parallel to the sampling bench to prevent heavy material from being mechanically deposited on the glass rather than air floated. The plates were set out at 9:30 a.m. The shop was cleaned at 8:30 a.m. and at 9:30 a.m. Cleaning time -- 10 minutes of each hour.

TABLE 7

SETTLING RATE OF HAND-CLEANING DUST

Plate No.	Time of Sampling	Sample Weight (mg)	Amount Gained (mg)
1	10:00 a.m.	11	11
2	10:30	15	4
3	11:30	17	2
4	12:30 p.m.	20	3
5	2:30	19	-1
6	4:30	23	1

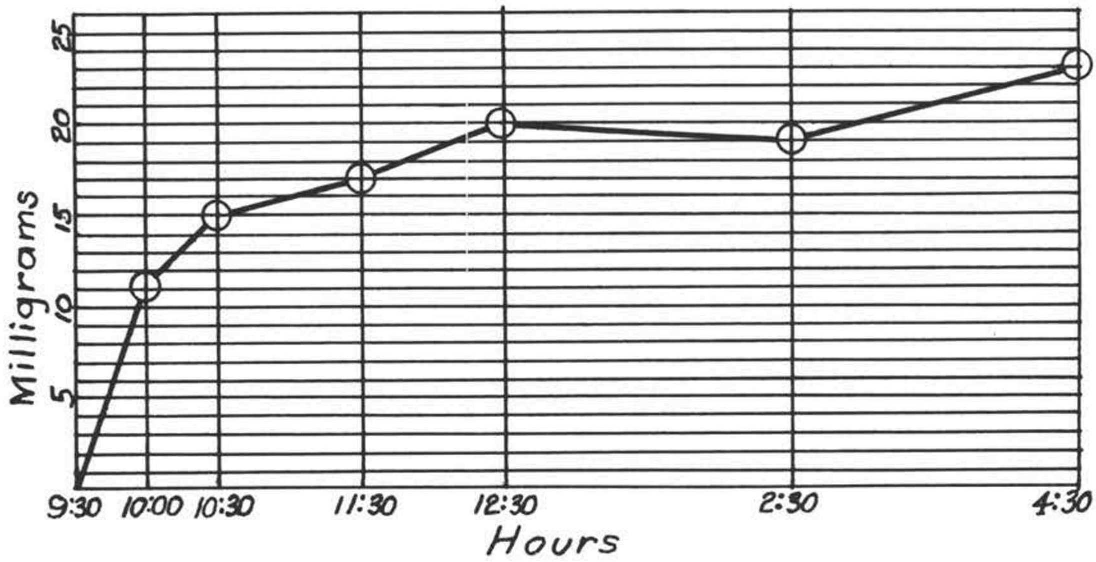

Plate I

Graph showing settling rate of dust activated by hand-cleaning methods.

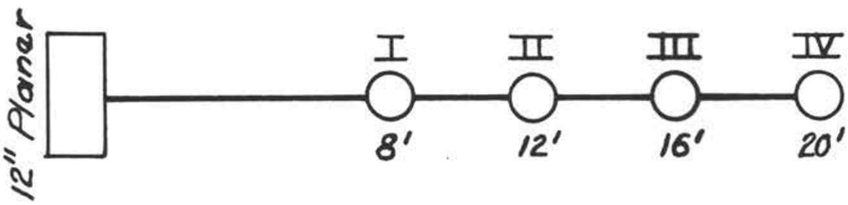

Plate II

Locationg of test stations for planer test.

As Table 7 and Plate I show, the greatest amount of dust fell during the first half hour, after which the amount per half hour greatly diminished. Forty-eight percent of the total amount weighed fell in the first half hour. Within three hours 87% of the total had fallen to the plates; this can be accounted for somewhat by the fact that dust on the benches was very light and easily airborne. Dust from the floor and nearer the machines would probably be heavier and tend to settle out faster. At 12:30 p.m. the air appeared completely free of dust and entirely comfortable to work in. No dust could be seen in the air except in strong sun rays.

Test to Determine the Distribution of Dust by a 12" Planer and to Test the Efficiency of a Unit Collector

One of the machines in the shop, a 12" planer, had a shavings and dust collector of the canister type attached to it. To check the ability of this machine to remove dust, the following tests were run.

1. Collector data:
    a. Type: Canister with cloth filter bag.
    b. Motor: ½ horse power, 3400 RPM
    c. Fan: 12" paddle-wheel type.

2. Planing data:

    a. Wood: Mahogany, 1x6x36

    b. Planing: 12 cuts each test, 1/16" deep.

3. Tests conducted:

    a. Three tests were run without collector in place.

    b. Three tests were run with collector in operation.

    c. Dust was allowed to settle four hours between test run and collection, then another test was started. There were three tests per day. (See Plate II, p. 44, for plan showing location of sampling stations.)

TABLE 8

PLANER DUST TEST

Test without dust collector attached

	Station I	Station II	Station III	Station IV
Test I	560 mg.	340 mg.	616 mg.	34 mg.
II	620	388	123	28
III	587	370	130	36
Average	589 mg.	366 mg.	289.6 mg.	32.6 mg.

Test with collector attached

	Station I	Station II	Station III	Station IV
Test I	6 mg.	8 mg.	6 mg.	- mg.
II	10	12	7	4
III	8	11	15	6
Average	8 mg.	10.3 mg.	9.3 mg.	3.3 mg.

According to the tests run on this collector, the machine appears to be very efficient. The percent dust removed at Station I was 98.7%; at Station II, 97.2%; at Station III, 96.8%; and at Station IV, 90%. The higher percentage at the stations near the machine indicates that the machine picks up the heavy material very well. The variable weights recorded with the collector in place are probably due to variability of air currents about the shop from the exhaust of the collector. All of the air drawn into the collector is exhausted into the shop through a hole 4"x5" at the bottom of the collector canister. This blast of air lifts dust from the floor or nearby machines and circulates it about the area. Any fine dust which escapes through the filter bag would also be blown into the shop atmosphere.

A Photographic Study of Dust

The purpose of this project is to determine the amount and the particle size of dust. The amount of dust in the air is of little value to the researcher on a health problem unless the size of the particles is also known. From previous experiments conducted by doctors and industrial health specialists, it has been established that the average size of wood dust particles is 90 microns (17, p. 262).

From information available it has been found that there is less danger of disease in the lungs than would appear likely and that the greatest threat is to the nasal passages (Dr. Rutherford T. Johnstone, 10, p. 386).

Prompted by statements in the references, a test was run in the shop to determine how the retention of dust in the nose and lungs would compare with the stated findings of Dr. Johnstone.

Following a working period in the shop in which considerable dust had been inhaled, a sample was taken from the nose contents. First the material was combined with water to make a solution which would separate the dust from the mucus. After the dust had settled out, a small sample was picked out with a medicine dropper and placed on a microscope slide where more water was added to make a very dilute solution. This solution was spread on the surface of the slide and allowed to dry after which the slide was placed on a micro-projector and the image of the dust particles projected onto a white piece of paper. To record the image of the dust particles, pictures were taken of the projected image, using an Exacta VX 35 mm. camera equipped with a 58 mm. f/2 Biotar lens (see Plate III).

Particles in this photograph average approximately 10 to 175 microns in length. To illustrate the

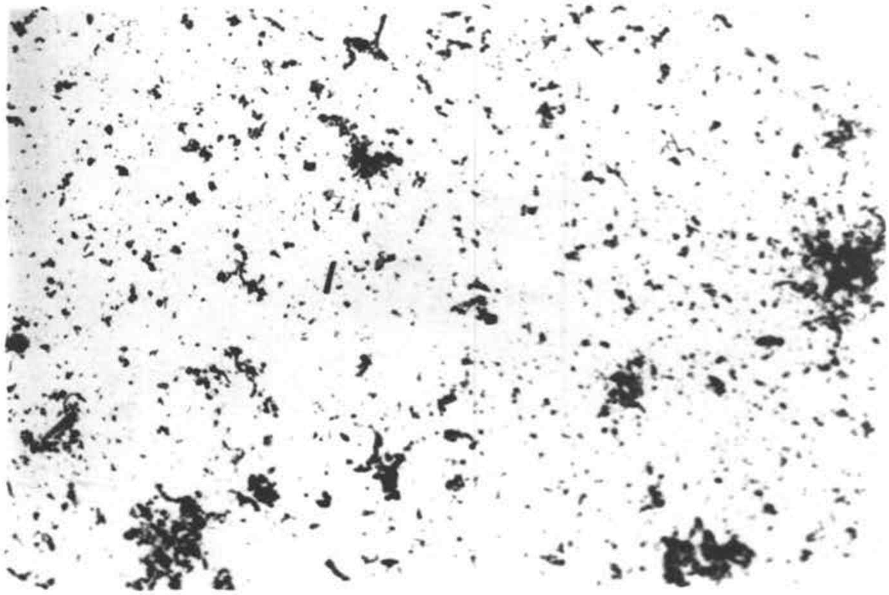

Plate III

Wood dust particles removed from the nose.

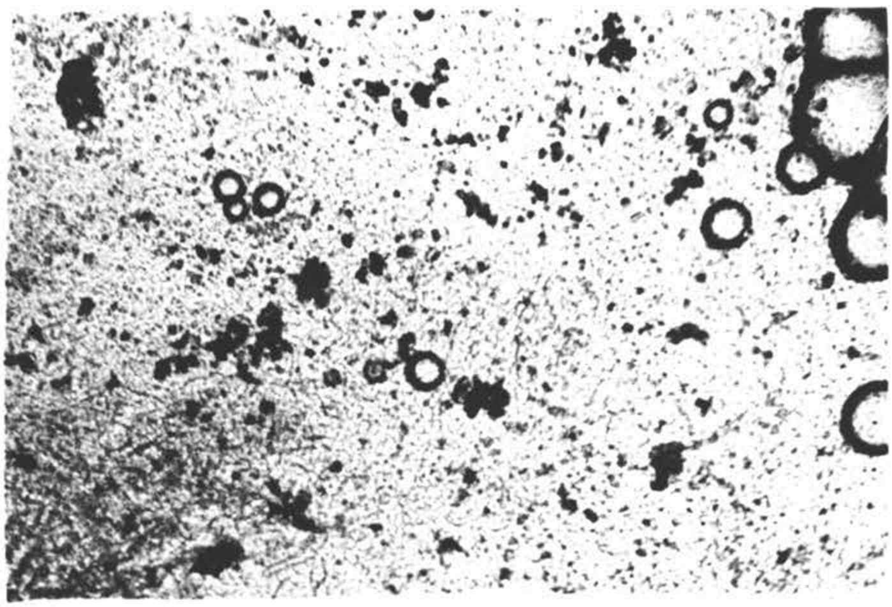

Plate IV

Dust samples coughed up from the trachea and bronchi.

efficiency of the nose as a filter system, another test was made using material coughed up from the trachea and bronchi. This material was treated in the same manner as the nose sampling except it was noted that water was less effective as a solvent. To get separation of this material, the mucus was spread on the slide and allowed to partially dry, after which it was spread with a razor blade, water added and the process repeated (see Plate IV).

In this picture the dust particles are the dark black spots. The light gray material in the background is dried mucus that was not separated from the dust. The black circles are tiny air bubbles in the mucus. The large black spots are clusters of dust particles. Individual dust particles appear to be (in comparison with measurable particles) approximately 10 microns in size and almost all of a uniform size.

Even after a person has worked in the shop for a long period of time and has a large accumulation of dust in the nasal passages, it is difficult to get a visible amount of dust from the lung area. This appears to be directly in line with the findings of previous researchers, that very little wood dust is small enough to find its way into the lungs.

Dust from the Planer (see Plate V)

In this sample the dust was taken from the air stream of the planer exhaust. The sample was picked up at a distance of 16 feet from the discharge point. Wood used for the test was Philippine mahogany.

Note the relatively large size of the particles. The fine lines on the picture are graduations on a blood counting chamber used to determine the approximate size of the dust particles. Squares in the squared, cross-hatched area are 1/20 mm. (50 microns). This allows one to estimate with reasonable accuracy the size of a particle down to 10 microns in length or diameter.

Fiberglass Sanding Dust

The possibility that fiberglass material might be a health hazard due to the small particles of glass finding their way into the lungs was explored. Wood particles that lodge in the lungs are absorbed by the body. Glass, a non-organic material, cannot be absorbed and might cause permanent injury, comparable to silicosis.

Material for the sample was collected on a piece of glass held at face level. A piece of fiberglass (boat seam covering impregnated with plastic) was sanded

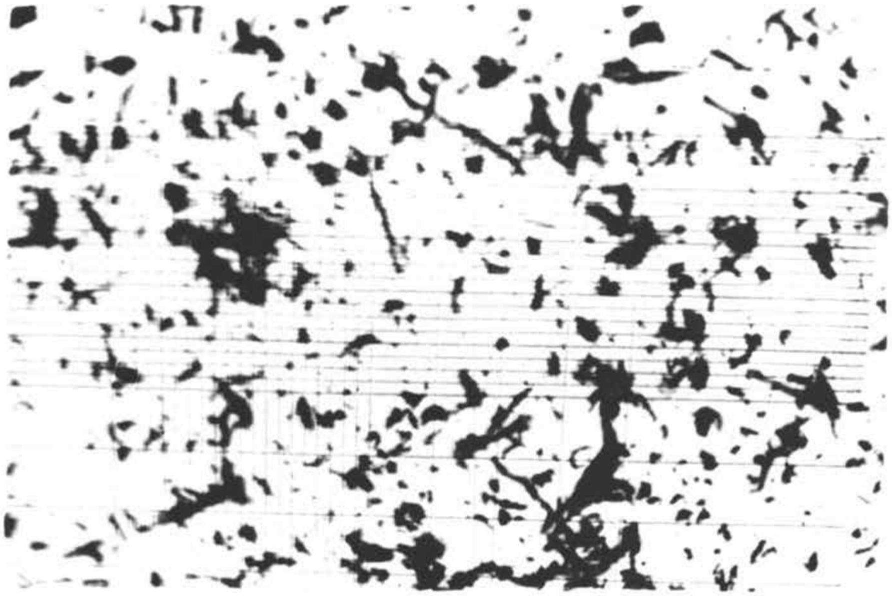

Plate V

Dust particles taken from the planer exhaust. Note the large size of the particles.

Plate VI

Dust from fiberglass material. Rod-shaped particles are glass fibers.

on a belt sander and the dust allowed to rise and settle on the sampler. The glass particles are the long, thin rods interspersed within the round or irregular particles of plastic.

In this sample it will be noted that the majority of the particles are glass, which would indicate that the glass is lighter in weight and will be blown farther by the air currents around the sander (see Plate VI). The sample taken in the hand-woodworking area of the shop appears to have some curled shavings of hand-sanding dust. Picture also shows many particles of 25 microns and less in diameter.

CHAPTER IV

METHODS OF DUST CONTROL

According to the survey reported at the beginning of this study, most of the industrial arts teachers believe every woodworking shop should have some method of collecting dust from the air. The real problem comes when the instructor investigates the possibility of installing a complete system only to find that the price is beyond the school budget and he must do without. This study provides an accumulation of information concerning the critical features of various systems, some commercial and some experimental, which should prove helpful to an instructor trying to decide which type of collector to install.

One purpose of this study is to present as many different dust control systems as is practical, with the hope that somewhere within the price range covered there will be found a method which will be satisfactory to the instructor and to the school budget officers.

Individual Machine Collectors

Shop Constructed Collectors

Considerable work has been done by industrial arts instructors in adapting various types of collectors to individual machines. Probably one of the most ingenious systems using shop-constructed collectors is located at David Douglass High School in Multnomah County east of Portland, Oregon. Here, used vacuum-cleaner motors and fans have been adapted to the various machines. Old-style upright cleaners were purchased at a nominal price, cut down to fit the machine and installed as a permanent accessory to the machine. Power for the 110 volt cleaner was taken from the machine switch. For greatest convenience the cleaner should be wired parallel with the machine motor so both motors operate through one switch.

Machines in the David Douglass school industrial arts plant to which these individual dust systems were adapted are: the band saw, radial saw, sander, lathes, and a small bench-mounted circular saw (see Plates VII and VIII).

Observations

The cleaners do a good job of removing the dust from small machines such as the small circular saw and the radial saw. On most machines the quantity of dust is not so great as to require frequent bag cleaning.

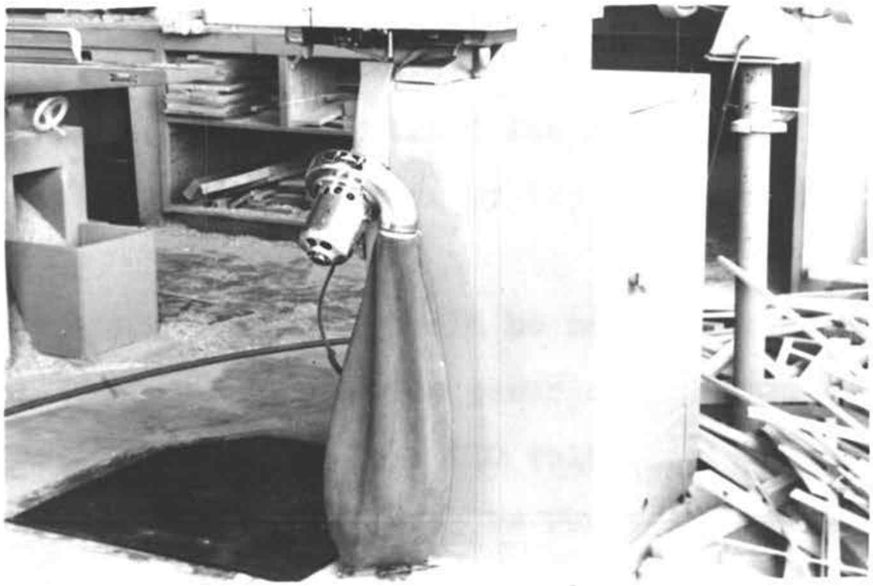

Plate VII

Vacuum cleaner motor attached to band saw.

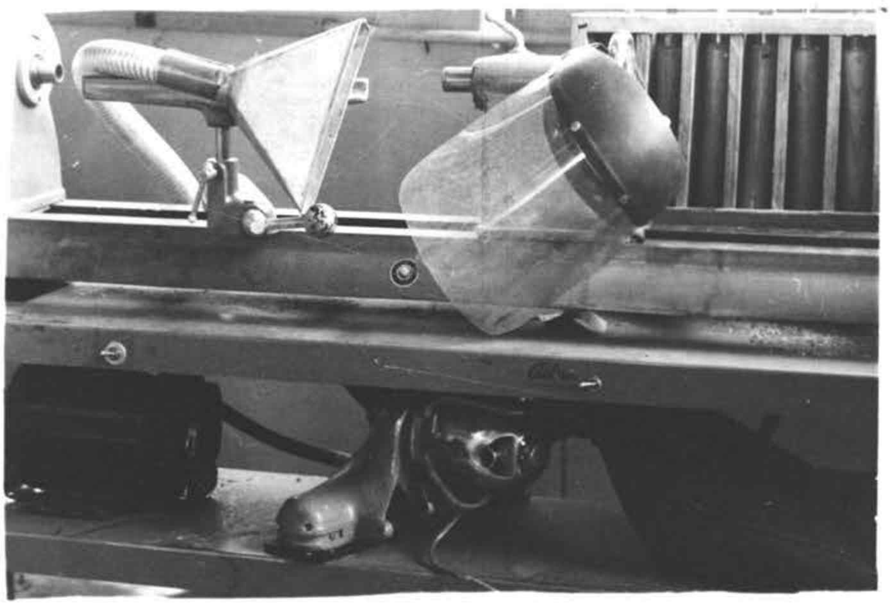

Plate VIII

Vacuum cleaner motor attached to lathe. Note collector hood on flexible hose.

The initial installation cost is low as the obsolete cleaners can be purchased for approximately $10 each and installation can be made by the students and instructor.

Two factors that should be noted in regard to this installation: (1) Check the power supplied to the machine motor. If other than 110 volt single phase is used, an additional line must be run to power the cleaner motor. (2) Use only good vacuum cleaner motors. A worn motor will be unsafe and a constant source of trouble.

Commercial Individual Machine Collectors

Several companies are now in the business of building the canister type individual machine collectors. These machines are usually well designed and do a good job, up to their capacity. One such collector tested indicated about 96% efficiency in removal of dust and shavings from a 12" planer (see Plate IX).

The design of these collectors is usually such that the dust and shavings do not go through the fan, thus preventing damage to the high speed fan should a solid object such as a block of wood get into the intake. Either the air is drawn through a bag inside the canister or a filter is placed on the outlet from the canister. One collector uses a paper filter similar to

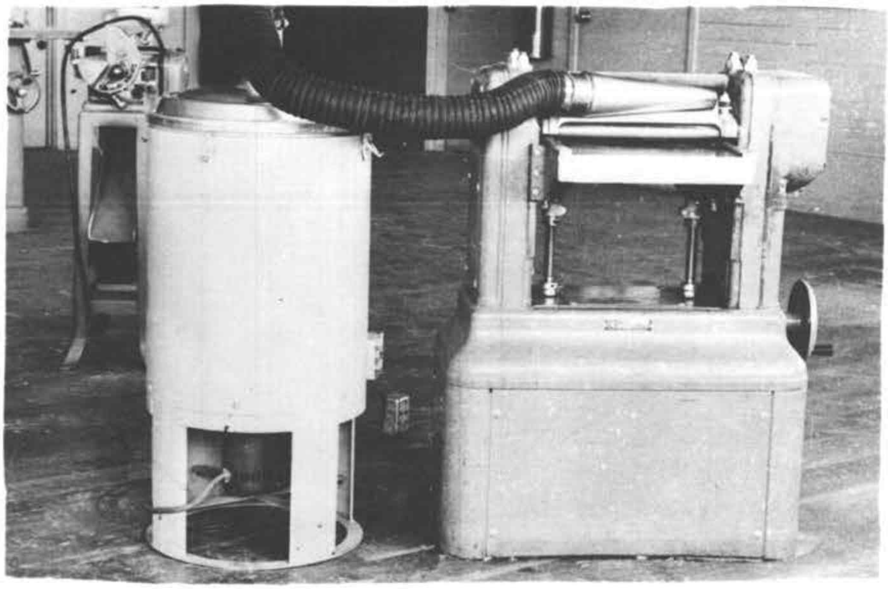

Plate IX

Canister type individual machine collector.

that used by some modern household vacuum cleaners.

It is quite easy to overload some canister-type collectors. Schools should be certain they get a machine with sufficient air capacity in cubic feet per minute and a large enough inlet opening to handle the material to be exhausted. Inlet pipe size should be at least 2½" to 3" in diameter. Air velocity in the hose will be less but the volume of air will be greater and the danger of clogging will be less in the larger size hose.

Canisters take up valuable floor space. If many machines are to be exhausted it would be advisable to investigate the possibility of a central system. The total cost of a complete exhaust system made up of individual collectors would probably come close to that of a central system, with less convenience and more floor space wasted.

Collectors with sufficient capacity may have their inlet passage branched and adapted to two or more machines. The volume and velocity of air in each branch would naturally be reduced. To compensate for the loss of velocity, screens can be installed in the machine hoods which would separate the heavy chips from the dust and allow the collector to handle only the air-borne dust. A collector thus fitted could collect dust from many more machines if it did not have to lift heavy shavings.

Separating Hood for a Planer

In shops where a dust collecting system has not been installed but a planer is used, many instructors have fitted the machine with a hood which is designed to contain the stream of shavings and dust from the cutting head and prevent the dust from being blown into the atmosphere. A skirt of canvas or like material also directs the waste into a box below the outlet. This hood can be made more efficient as far as the dust is concerned if a suitable screen is placed in the top of the hood and the hood is exhausted by a vacuum system.

A separator of this type could be adapted to the vacuum cleaner system or the type using a common canister collector with several machines exhausted at once. Separators of this type would allow several machines to be exhausted by one comparatively low-power and inexpensive blower system which would be easy to install and quiet in operation.

Built-up Collector Systems

During the past few years several companies have made available to the industrial arts teachers component parts of dust collecting systems. With these parts (blower, separator, pipe, elbows, etc.) the instructor can assemble his own unit to suit his needs and budget.

Before a person attempts to design his collecting system he should become familiar with several books on dust control elements to better understand the problems of design and to be able to recognize some of the obvious pitfalls a beginner may meet. Probably one of the best books on the subject is Alden, John L., Design of Industrial Exhaust Systems. It is written in non-technical language which the layman can understand. Other references in the bibliography would be helpful to one seriously studying the theory of air flow and separation.

Air Volume Measurement

In the design of an efficient dust collector there are several important factors which must be calculated. One of these is the volume of air flowing in a pipe. This is measured in cubic feet of air per minute. Below is a table that reads directly in cubic feet per minute (CFM) when the size of the pipe and the static pressure inside the pipe is known.

Static pressure is that air pressure necessary to overcome friction within the pipe. This static pressure

TABLE 9

CUBIC FEET OF AIR HANDLED PER MINUTE
THROUGH AVERAGE COLLECTING HOODS
(3, p. 462)

Diameter of pipe in inches	Maintained suction, inches water gauge (static pressure)						
	1"	1½"	2"	2½"	3"	4"	5"
1½	38	47	54	61	67	76	86
2	68	85	97	108	119	136	153
2½	107	131	161	168	185	214	238
3	153	188	217	243	266	306	343
3½	209	256	296	330	362	418	466
4	273	334	386	431	473	546	609
4½	345	423	488	546	598	690	775
5	427	533	605	676	741	854	955
6	614	751	867	970	1062	1228	1373
7	835	1023	1180	1322	1448	1670	1870
8	1092	1337	1546	1727	1892	2184	2440
9	1381	1695	1953	2184	2387	2762	3091
10	1705	2090	2409	2695	2959	3410	3806

may be either plus or minus according to whether the test is made at the inlet or the outlet of the blower.

One of the simplest methods of determining static pressure is by use of a manometer, a U-shaped tube of glass fastened to a scale graduated in inches and fractions of inches. The tube is partially filled with water and a small rubber tube is fastened to one end.

To check static pressure, drill a fine hole (1/16" or less is sufficient) in a straight section of the pipe to be checked. To insure accuracy when testing for suction, the test hole should be at least seven pipe diameters from the entrance. Remove all burrs from the hole inside the pipe to make possible an even flow of air past the hole. Hold the free end of the rubber tube from the manometer over the test hole. Suction within the pipe will draw water up in one leg of the upright manometer. The difference, measured in inches, between the water levels in the two legs is the static pressure. By checking the static pressure and noting the volume flow of air as indicated on the chart, one can soon find if the blower has enough power to adequately exhaust a particular machine.

Air Volume Requirements

As one goes about the job of assembling parts for his collecting system the first determination is the size of the blower and separator needed. As this unit will be the most critical and expensive, the purchaser should be assured that the capacity is adequate for his requirements, plus a reserve for effectiveness and for future additions to the shop equipment. Be sure to have a system that has enough reserve capacity to take care of such additional attachments as floor sweeps and larger replacement machines.

Table 10 lists the common machines with exhaust pipe size and inches of water drawn in a manometer to adequately remove all dust and waste material from the machine.

TABLE 10

BRANCH PIPE SIZES AND STATIC SUCTION AT HOOD
(1, p. 58)

Machine	Size	Branch Pipe No.	Branch Pipe Diam.	Static Suction	CFM
Planer Single	up to 20"	1	5	1.50	532
Horiz. belt sander	up to 6"	1	4	1.50	334
Disc sander	up to 12"	1	3½	1.50	256
Table saw	up to 16"	1	4	1.25	300
Radial saw	up to 20"	1	4	1.25	300
Band saw	up to ½"	1	3	1.25	170
Jointer	up to 6"	1	3½	1.50	256

Separator Systems

It is one problem to remove the dust and shavings from the machines and yet another problem to separate the material from the air stream. If the air is to be exhausted outside, the complete separation is of less importance than if the air is to be returned to the room where a very high percentage of even the very small particles must be removed.

To be an acceptable separator for the woodworking industry, the unit must be able to: (1) handle a large volume of material, (2) handle a large volume of air, (3) separate a large percentage of the material from the air, (4) work with little back pressure, (5) operate with little expense.

The following several separators have been investigated and found to be useful in separating materials in woodworking shops. Some are more adaptable as pre-cleaners while others are suitable for final cleaners.

Settling Chamber Separator

Dust and shavings will separate from an air stream to a large degree if the velocity of the air is suddenly lowered. Air which is blown into a large container, such as a dust bin, will drop much of its load before it exhausts out the far side. An elbow at the inlet which directs the air stream downward and a series of baffles in the box to slow down the stream in the exit would remove all but the fine dust. A school shop which was isolated could use such a system as the dust which was discharged would not cause a nuisance. The larger the settling chamber the more efficient will be the separation.

Aerodyne Cone

The aerodyne cone is a method of precleaning the air before it is finally separated by some other means. This separator consists of a long, tapered steel cone with horizontal slits cut around the surface. The air enters at the large end and escapes through the slits as the cone narrows and the pressure builds up. Dust and shavings pass on by the slits and are removed out the small end of the cone. From the end of the cone the shavings go into a cyclone, hopper, dust bag or some more efficient separator. The aerodyne cone would be an excellent separator to use in conjunction with the settling chamber.

Cloth Filter Separator

The fact that air passing through a fabric will be partially cleaned has long been recognized. The obvious explanation for separation is that the dust is screened from the air as it passes through, due to the small spaces between the fabric threads. This theory is only partially true for it would soon be seen, if one were to examine the cloth under a magnifying glass, that the spaces between the threads are much larger than the dust particles separated. As in most filtering situations, the filter does not clean effectively until a layer of the material is built up on the fabric and the air passes through a filter of very fine dust particles. When a new filter is installed there will be a small leakage of dust particles until the cake gets built up within the bag or filter cloth.

The thicker the cake on the fabric the more efficient will be the filtering action but, as the cake builds up, the capacity of the system diminishes. There must be a system of cleaning the cloth surface included with the filter to make it practical for the wood shop.

Several types of cloth have been used successfully as filters. There is a special cloth used specifically for dust bags on vacuum cleaners. Sheeting, muslin, flannel and wool suiting have all been used and found satisfactory substitutes for the special cloth. Recently synthetic materials have been adapted for dust bags.

Providing a shop has the necessary space available, a combination of settling chamber, aerodyne cone and cloth filter on the exit would make an effective, inexpensive separator.

Cyclone Separators

Low Velocity System

Probably the most common type of separator in the woodworking industry is the low velocity cyclone. The advantage of this unit is the fact that it will handle a large quantity of material with a minimum of attention. Occasional blocks of wood, splinters, etc., will pass through the separator with no damage to the equipment. The efficiency of a low velocity unit is fair. Efficiency falls off rapidly as the particle size decreases to the 10-20 micron range.

Operation of a Low Velocity Cyclone

To understand the limitations of a cyclone one must understand how material is separated from the air stream in such a separator (see Plate X).

Plate X is a drawing of a typical low pressure cyclone. Air enters in a thin stream at the top, tangentially to the inner surface. As the air spins inside the cone, entrained dust and material is deposited on the walls of the separator by centrifugal force. Air and dust are forced down the cone in ever tightening spirals through action of air pressure from the inlet. As the diameter of the cone decreases the speed of the

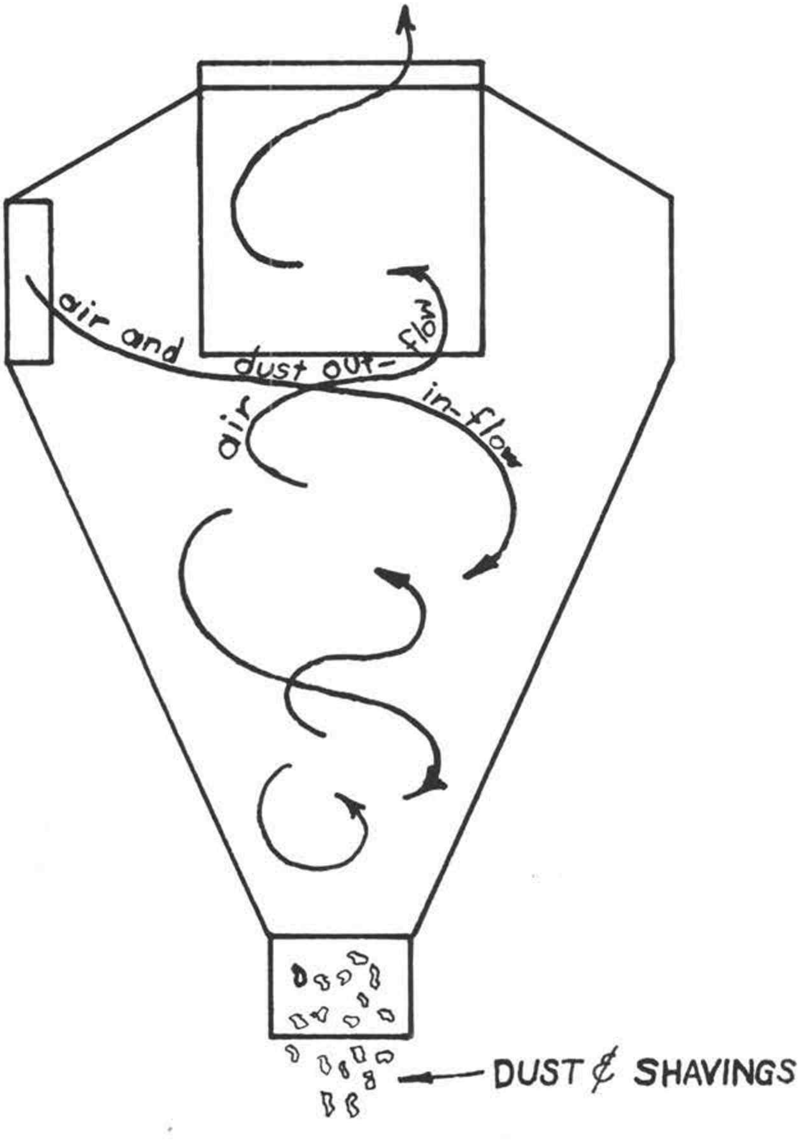

Plate X

Schematic drawing of low pressure cyclone separator.

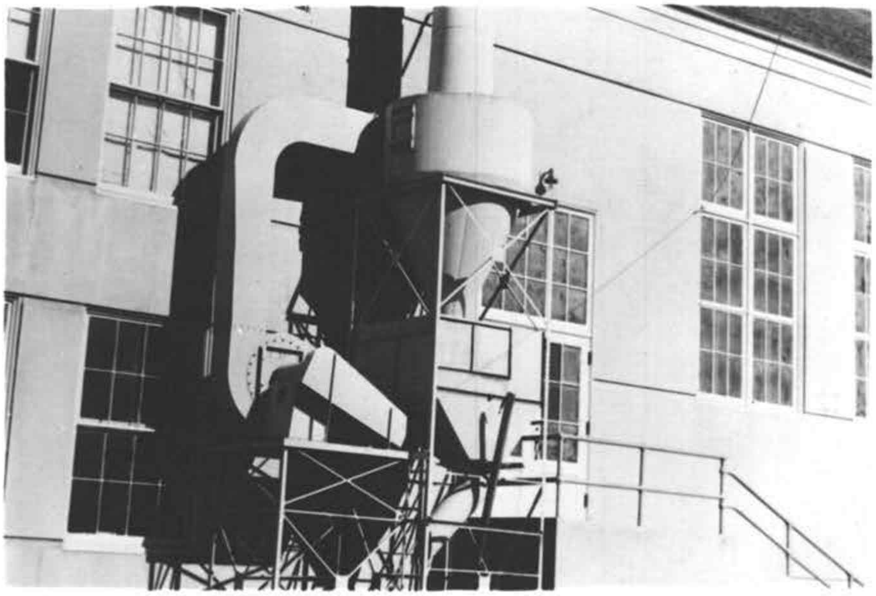

Plate XI

Low pressure cyclone installation, Corvallis High School, Corvallis, Oregon

Plate XII

TORIT, Model 219 high velocity cyclone separator.

flow and centrifugal force applied to the dust particles increase. The dust is pressed tightly against the wall of the cone and slides downward in an ever diminishing spiral path. The air, which, as it passes downward, is compressed into a smaller and smaller space, makes its way to the center of the cone where it creates a new spiral and escapes upward through the top of the cyclone while the dust drops out the bottom. There are two vortices in a cyclone. One on the outside is large and contains air and dust. The other is a smaller helix that is rising in the center of the cyclone and is made up mostly of air alone.

The low velocity separator is quite adaptable to the woodworking industry because it is quite efficient under heavy loads of material. Cyclones can be made to handle very large volumes of air.

High Velocity Cyclone

Within the past few years the cyclone has been improved to make it more efficient on the smaller sizes of material. As the principle of operation of the cyclone is based on centrifugal force, any means of getting more force against dust particles would cause them to cling tighter to the cyclone wall and thus be separated from the air stream. In the high velocity cyclone this is accomplished by making the cone much smaller in diameter and much longer in taper length. As air enters a high velocity cone it immediately is thrown into a very tight spin. As the air travels the length of the long tapering cone the speed mounts to the place where even the very small particles are affected by the centrifugal force and are thrown out of the air stream and against the side of the cone. As in the low velocity separator, the dust slides down the sides of the separator in a spiral path and finally falls out the bottom. The air exhausts up the center and out the top.

The high velocity unit must necessarily be of much higher precision than the low velocity cyclone. The inner surfaces of the cone must be very smooth and free from irregularities. At the high speed at which the air travels, any roughness would cause eddy currents in the air, upset the separation action and move the dust particles back into the central air stream.

The efficiency of the high velocity cyclone is much higher than that of the low velocity but the capacity is lower due to the smaller size of the cone. If the unit is to exhaust outside where the exhausted dust would be no problem then a low velocity unit would be satisfactory. The high velocity unit is recommended where the exhaust is to be filtered and returned to the room as the amount of dust captured by the filter is small and does not materially hamper the flow of air through the filter.

Rotoclone System of Collection and Separation

The American Air Filter Company, Louisville, Kentucky, has perfected a system of combined blower and separator unit which has been trade named "Roto-Clone."

The rotoclone uses centrifugal force to separate the material from the air stream but the system is unique in that the separator and blower are combined in one unit. The fan is made up of a great number of small, curved blades attached to a circular plate. This unit looks very much like the rotor in a turbine. This impeller is enclosed in a scroll-type cast iron housing (see Plate XIV).

Dust-laden air from the machines is drawn in at the center of the impeller. Heavy dust particles hit the fan and are caught up by the curved, troughlike blades. Fine dust particles are caught as the air is drawn into the fan blades. Centrifugal force of the high speed fan forces the dust particles to stay in the trough-shaped blades and moves them out to the tips of

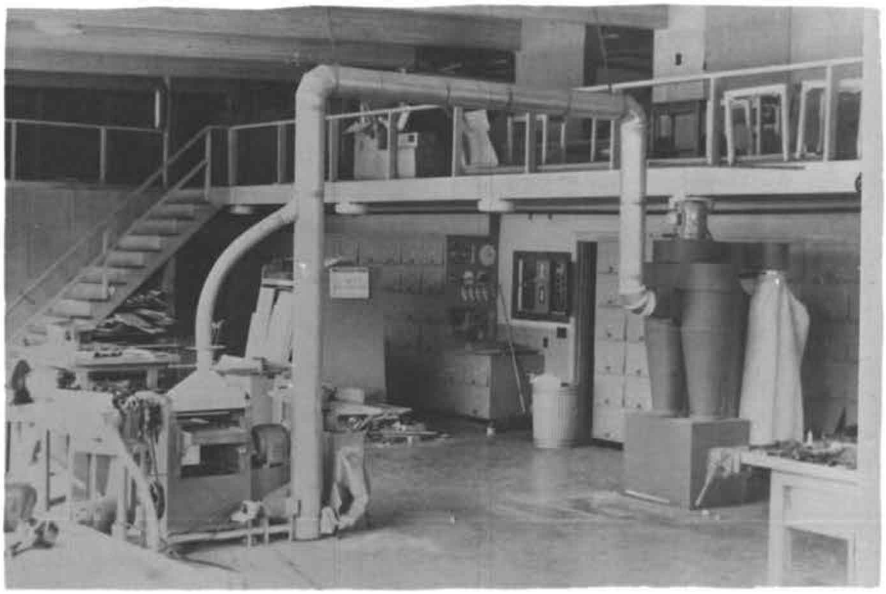

Plate XIII

TORIT, Model 219 high velocity cyclone system installed in a typical woodworking shop situation

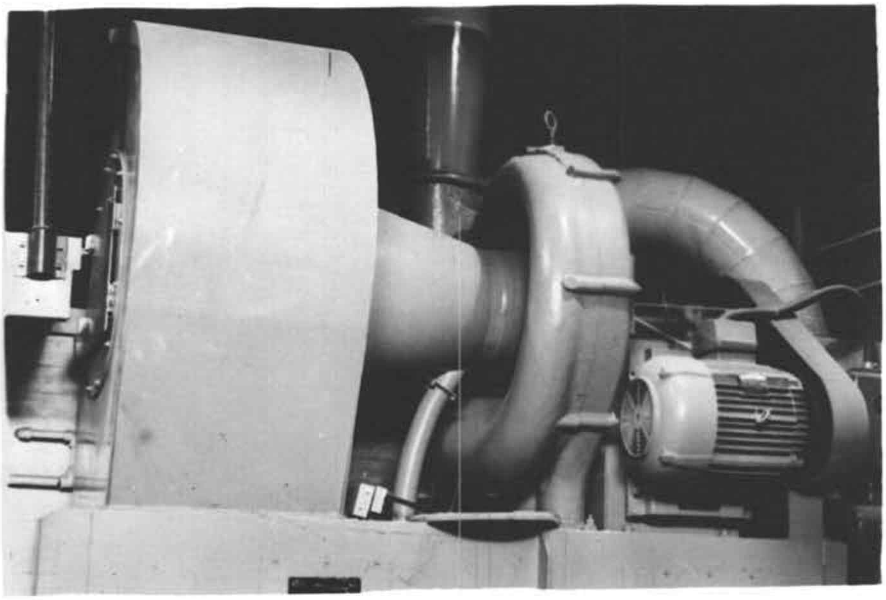

Plate XIV

ROTOCLONE separator. Skimmer (pre-cleaner) on the left; inlet (curved pipe) on the right.

the blades. These tips extend out of the main chamber of the blower, through a narrow slot in the casing, and enter a secondary chamber surrounding the main blower. Here the dust particles are deposited to be drawn off into a hopper while the main body of air in the large chamber moves out through the general outlet.

The efficiency of the unit is very high on fine material of heavy weight and low concentrations. When heavy concentrations are to be separated or if heavy material such as planer shavings are to be separated then a pre-cleaner should be installed ahead of the rotoclone. The American Air Filter Company uses a pre-cleaner called a skimmer to remove the great bulk of material from the air. Material-laden air is drawn into the skimmer at a tangent to the inner surface of the container. As the air and materials spin around the inside, the concentrated material that has been thrown against the surface of the chamber by centrifugal force is drawn off through a narrow slot in the curved surface. This material, with a small amount of air, is deposited in a closed hopper. The air is led off into the rotoclone through a pipe connected from the top of the hopper to the intake of the rotoclone.

Electrostatic Precipitators

Some questions have been raised about the possibility of using electrostatic precipitators to remove shop dust from the air. This section of the report is to bring to the reader some facts concerning the operation and capabilities of the electrostatic precipitator.

The precipitator consists of a large box-like unit containing electrodes of positive and negative polarity. As the dust-laden air is drawn past the first set of electrodes, dust particles are given a negative charge which causes them to be attracted to and adhere to the second set of plates which are charged positive. To charge the particles and cause them to adhere to the plates, a high potential of 60,000 to 70,000 volts direct current must be maintained at all times. To be efficient, the electrodes must be operated at near the spark-over point to provide a corona around the negative electrodes.

The unit is operated until the positive plates become loaded and are unable to hold more dust, after which the current is turned off and plates are cleaned either by brushing or vibration.

The electrostatic precipitator is not yet practical for the woodworking shop for several reasons:

1. The cost is prohibitive. A precipitator capable of handling the large volume of air would be of tremendous size. Most precipitators operate at 100 to 600 cubic feet per minute.
2. Fire danger is too great. The precipitator operates at near spark-over potential and if a spark were to ignite the dust in the cleaner it would cause a dust explosion and fire. Precipitators should be used only on non-flammable materials.
3. The danger of electrical shock is high, especially where children are involved.

The precipitator may be used as an air filter when a small amount of air is passed through the unit. In air conditioning and heating units the filter is used to clean a fraction of the circulated air as it passes through the central blower system. This air would have a small concentration of dust to be removed. These units are also of a much lower voltage rating. The precipitator is very efficient on small particles of dust or even particles of smoke.

Considerations of Air Supply

When one plans an exhaust system he must take into consideration the source of air to operate the dust removal system. If the blower requires 3000 CFM to evacuate the dust from all the machines then there must be a supply of air that quantity from somewhere to replace the discharged air.

Systems using air filters that clean and return the air to the room have no problem here; but when the air is exhausted outside several problems appear. These are listed as follows:

1. Can air be drawn from other parts of the building?
2. If air is drawn from the outside, will the temperature of the building be lowered excessively?
3. If the air is drawn from the outside, can the air be tempered to prevent cold drafts?
4. Can an outside exhaust be located in such a place that dust will not be drawn back into the building?

Shops located in the main school building may get their air supply from the halls. In a large building the halls are seldom ventilated so the removal of inactive air is desirable. Heat in the halls is maintained through escape from the adjacent rooms and from student activity. The Corvallis High School system is a good example of this type of air supply.

In some areas where the shop is located in a separate building the loss of heat becomes critical. A large central system which evacuates from all the major machines in the shop may discharge as much as 3000 cubic feet per minute of heated air and draw into the building a like amount of cold air. At this rate a shop 40'x60'x15' would have the air changed once every 12 minutes. If the temperature inside the shop were 65° and the outside were 32° one can quickly see what a load is thrown on the heating plant to maintain a comfortable temperature.

To calculate how much it would cost to heat a shop during the winter if all air were exhausted outdoors, the following chart was made. Winter months of November, December, January, February and March only were used. Sample temperatures were averaged for the typical climate areas of the state.

The formula used to calculate heat loss was:

$$\frac{\text{CFM of system} \times 60 \text{ minutes} \times \text{temp. difference} \times 805}{55 \text{ cu. ft. per BTU} \times 7000 \text{ BTU per lb. of coal} \times 2000}$$

CFM in air evacuated per minute.

60 minutes per hour.

Temperature difference between inside and outside.

805 hours during heating season.

55 cubic feet of air heated per Btu.

7000 Btu (net heat available to the space).

2000 pounds of coal per ton.

The above calculations will give the required tons of coal to heat the exhausted air.

Sample problem: apply to Burns, Oregon, area.

1. Average temperature for 5 winter months - 30°.
2. Cubic feet per minute of collector - 2000.
3. Temperature maintained inside - 65°.
4. Operating hours per heating season - 805.

$$\frac{2000 \times 60 \times 35 \times 805}{55 \times 7000 \times 2000} = 4.39 \text{ tons of coal per season.}$$

Cost: 4.39 x \$20 = \$87.80 to maintain the shop temperature at 65°. This cost would be above that required for a shop without an exhaust system. Variations in cost of fuel and cubic feet per minute would alter final individual cost figures.

TABLE 11

AMOUNT OF COAL USED TO HEAT EXHAUSTED AIR
IN TYPICAL CLIMATIC AREAS

Temperatures are 1956 averages for the months November through March inclusive, taken from the official U. S. Weather Bureau report. Formula figures same as above in text.

City	Average Outside Temp.	Tons of Coal
Albany	41	3
Arlington	38	3.38
Ashland	38	3.38
Astoria	41	3
Baker	28	4.6
Bend	34	3.8
Burns	30	4.3
Cottage Grove	41	3
Eugene	41	3
John Day	34	3.8
Klamath Falls	34	3.8
Nyssa	33	4
Pendleton	36	3.6
Portland	40	3.14
Prineville	35	3.7
Reedsport	44	2.6
Grants Pass	41	3

CHAPTER V

DUST CONTROL DEVELOPMENTS AND COMPARISONS

As a result of information gathered from industrial arts instructors concerning their dust control needs, an inexpensive system was developed and tested. The plan was to develop a system that was easy to construct, inexpensive, easy to maintain, and so constructed that it would not remove heated air from the building. A machine which shall be referred to hereafter as an "atmosphere filter" was the result of this planning.

Atmosphere filter

An atmosphere filter as used here is a system of filtering that will remove dust from the room air irrespective of how it was produced.

Dust is liberated into the air by many types of activities. Operations such as power machines, sanding, cleaning activities, etc., all add their particular type of dust to the air. It has been found through previous studies (14, p. 8) that woodshop dust settles out of the air rapidly. Given a quantity of very fine wood dust released into the air by a blower, 48% of the dust will have settled to the surface within the first half hour.

When activity is going on in the shop a constant supply of new dust is being added to the air. Dust on machines and tables is also disturbed and again becomes airborne.

Previous to this experiment the author theorized that if a large volume of air could be drawn through a filter system the air in the shop could be kept at a comfortable level of dust contamination. Air exhausted from the filter would not be blown outside but would be returned to the room to be recirculated. By this method valuable warm air would not be wasted during the winter.

For the conduct of the experiment a box was constructed (see Plates XV and XVI) which contained three 14"x25"x2" spun glass filters of the type used to filter air in forced air furnaces. To exhaust the air a 16", 4 blade aluminum fan was mounted on a ¼ horsepower electric motor. The assembly was mounted in the box in such a manner as to draw the air through the filter, into the box and exhaust it out the other end. By drawing the air through the filter from the outside, the operator could observe the filters and note when they needed to be replaced. This method would also discourage possible tampering with the machine by students who might want to throw material into the fan.

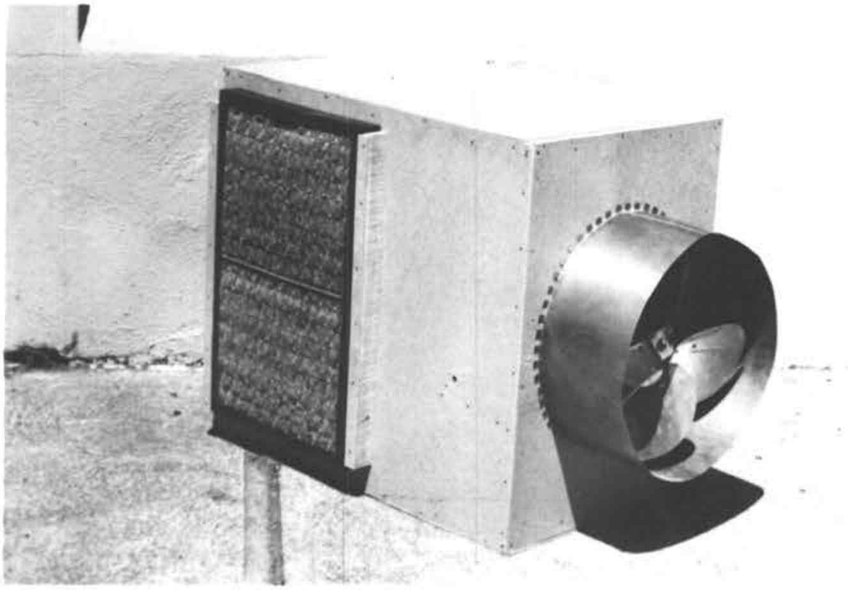

Plate XV

Atmosphere filter with filter pads in place.

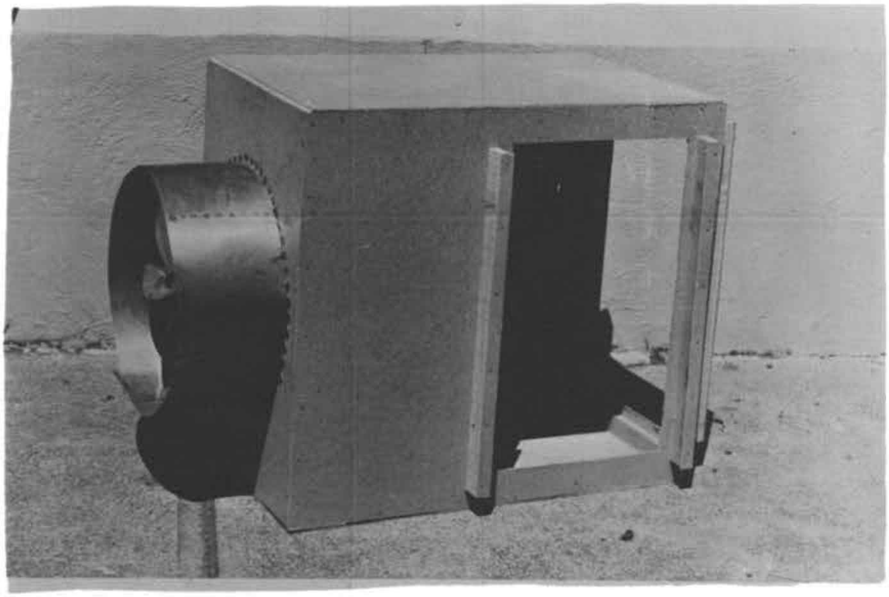

Plate XVI

Atmosphere filter without filter pads in place.

<u>Conduct of the Atmosphere Filter Test</u>

To test the theory that such a filter would remove dust from the air at a practical rate, the unit was taken to a woodworking shop which did not have a dust collecting system. The shop had been used by the maintenance men since the close of school (approximately two months) and a great amount of dust was on all flat surfaces. Most of the dust was either of maple or oak wood as this was the material which was being machined.

To start the test, seven glass plates, 9"x12", were placed on a table in the central part of the shop. These plates were then covered with a paper until they were needed. Dust in the shop was then scattered and blown into the air with a blower from a commercial vacuum cleaner. When a heavy concentration of dust was in the air the paper was removed from the plates. After one minute had passed, the first plate was picked up and the succeeding plates were picked up at five minute intervals. Accumulated dust was removed from the plates with a razor blade, placed in a paper folder, marked for identification and later weighed on an analytic balance.

To test the collector, the same test was run with the collector in operation after the first minute. This first minute collection was made during both tests to give a comparison of the amounts of dust in the air at the start of the tests. From information gathered, the following table was made.

TABLE 12

ATMOSPHERE FILTER TEST

Test I - Free dust settlement (weights in milligrams)
Test II - Settlement with atmosphere filter in operation (weights in milligrams)

	Minutes						
	1	5	10	15	20	25	30
Test I	10	34	46	50	50	53	48 mg.
% total deposit	0	64.2	86.8	94.2	94.2	100	91.6
Test II	9	17	18	18	20	21	22
% total deposit	0	73.9	78.3	78.3	87	91.3	100

Total Deposit, Test I, 53 mg.

Total Deposit, Test II, 22 mg.

Percent Collected by Filter, 58.5%

The filter cleared the air much faster than was expected. Within the first 5 minutes approximately 74% of the dust had been cleared from the air. Total space in the shop was 48,000 cubic feet. The fan was capable of moving 3400 cubic feet of air per minute.

Test of Atmosphere Filter in Actual School Shop Conditions

Following the above experiments, it was decided to conduct a test of the air filter in a woodworking shop while school was in operation to determine how well the apparatus would control dust. The machine was set up in the woodworking shop of the McLoughlin Union High School, Milton-Freewater, Oregon, during the winter term.

The only dust control equipment normally used in the shop is a canister type, individual machine collector attached to a 12" planer. For some phases of the experiment this machine, including the collecting hood, was completely detached from the planer.

During the experiments, four sampling stations were set up around the shop. These stations consisted of pieces of glass 12" square on which dust samples were collected. The stations were located in the following areas:

I - In the machine area directly behind the planer exhaust.

II - In the hand-woodworking area.

III - In the storage area.

IV - In the general machine area.

Each sampling experiment was run for a period of three weeks to obtain a long-period average of dust accumulation. Dust was allowed to accumulate for one week after which it was collected and weighed. The total of the three week collections was used as the comparative figure.

Test I - Normal dust concentration in the shop

To determine the normal amount of dust produced in the shop, all dust control equipment was made inoperative. The canister collector and collecting hood on the planer were removed and the atmosphere filter was not used. Four sampling plates were distributed around the shop. Normal operation in classrooms was observed during the test.

In this test, as well as all others conducted, shop activity consisted of:

1. Woodworking I (2 periods, 20 students each).
2. Woodworking II (1 period, 22 students).
3. Woodworking III-IV (1 period combined woodwork and carpentry, 15 students).
4. Mechanical drawing (1 period, 18 students).
5. Teacher preparation period (1 period, students permitted to work in the shop to do extra work).

Dust collection averages - normal dust concentration.

Station I	402 milligrams
Station II	220 milligrams
Station III	182 milligrams
Station IV	164 milligrams

Test II - Atmosphere filter in operation

Same general test arrangement except that the atmosphere filter was placed in operation. This machine was placed against a wall and set to exhaust the cleaned air in the direction of the long way of the room. The filter was placed 8 feet in the air close to the major dust producing machines (planer, sander and lathes) with the assumption that air drawn in from these machines would be cleaned, exhausted, and re-circulated about the room to bring more dust-laden air back to the filters. The filters were three spun-glass type disposable furnace filters mounted in the three sides of a box. Air circulation was accomplished by use of a ½ horsepower, 1725 RPM motor attached to a 16" three-blade fan. This combination moved approximately 3400 cubic feet of air per minute. This machine was placed in operation at any time a dust producing activity was taking place in the shop.

Dust collection with atmosphere filter in operation.

		% decrease from normal
Station I	290 milligrams	28
Station II	62 milligrams	72
Station III	56 milligrams	69.3
Station IV	38 milligrams	76.8

Total average decrease 61.4%

Test III - Canister collector in use

In this test the atmosphere filter was not used but the individual collector attached to the 12" planer was used. The collector motor was wired through the planer switch which caused the collector to be operated only when the planer was being used.

Dust collection with canister collector in use.

		% decrease from normal
Station I	165 milligrams	59
Station II	185 milligrams	16
Station III	103 milligrams	43
Station IV	77 milligrams	53

Total average decrease 42.8%

Test IV - Canister collector and atmosphere filter

During the final three weeks of the tests, both the atmosphere filter and the individual machine collector were used. The filter was again operated at all times when dust producing activities were in operation.

Dust collection with atmosphere filter and canister collector in use

		% decrease from normal
Station I	182 milligrams	54.6
Station II	54 milligrams	75.5
Station III	43 milligrams	76.4
Station IV	49 milligrams	70.1

Total average decrease 69.1%

Observations

1. From the charts it will be seen that on the average the canister collector alone removed approximately 42% of the airborne dust and the atmosphere filter removed 61%. When both machines were used the amount of dust deposited on the plates was reduced 69.1% compared to the collections when no control systems were used.
2. The noise of the fan in the air filter was not excessive although it is believed that a lower speed

motor (1200 RPM) would be nearly as effective and less noisy. The filter fan was a little more bothersome than the heater fan on the space heater.

3. The use of the filter aided materially in reducing the dust concentration in the air, making the shop more comfortable to work in.

4. Total cost of the air filter was low in comparison to other control systems.

¼ HP electric motor, 1725 RPM	$21.00
16" three blade fan, 30 degree pitch	4.75
Three 16"x25"x2" glass dust filters	4.92
1 plywood filter box (approximate cost)	8.00
Total	$38.00
Additional cost for permanent type metal or plastic filters	22.08
Total	$60.75

Comparative Costs and Efficiency of Selected Dust Collecting Systems

The information below is an attempt to give comparative data concerning average costs and collecting efficiency of some of the collecting systems previously described.

There appears to be no method of getting a direct comparison due to the different purposes for which the machines are bought and the varying amounts of attachments needed in different shops. In most of the units surveyed, the price for the main collector is stated but the buyer would have to calculate his requirements for pipes, elbows, shut-offs, etc. The column marked COLLECTING ABILITY is an attempt to give a comparison under normal operating conditions.

UNIT TYPE	COLLECTING ABILITY	PRICE RANGE
Atmosphere filter	Airborne dust only, 60-70% reduction in atmosphere dust load	$50 to $150
Canister collector	90% efficiency, dust and shavings from individual machine	$89 to $210
Instructor assembled systems		
HARADEE Model 30A Blower with motor, switch, and attachments for 2-3 machines	Dust and shavings from 12" planer and 2 small machines	$270 to $325
HARADEE Model 70A Blower with motor, switch, and attachments for 2-3 machines	Dust and shavings from 20" planer and 2 small machines	$388 to $450
HARADEE Model 70A Blower with motor, switch, and attachments for overhead piping to six machines	Dust only	Above prices plus $150 for pipe, elbows, flex. pipe, etc.

UNIT TYPE	COLLECTING ABILITY	PRICE RANGE
TORIT systems (high velocity cyclone)		
TORIT Model 13 High efficiency cyclone, 450 CFM, with attachments for 3 machines, including filter bag	Dust and shavings from 20" planer and 2 small machines	$375 plus pipe
TORIT Model 19 1200 CFM, with filter bag	Dust and shavings from 12" planer, 12" disc sander, ½" band saw, and either 10" table saw or 10" radial arm saw	$498 plus pipe
TORIT Model 219 2125 CFM, with filter bag	Dust and shavings from 20" planer, 6" horiz. sander, 12" disc sander, 10" table saw, 6" jointer, 10" radial arm saw, ½" band saw; above estimate providing machines are not widely separated	$710 plus pipe
TORIT Model 24 3000 CFM, with filter bag	Large enough to handle all but the largest shops with large planers and jointers	$1130 plus piping

Low Velocity Cyclones

Because there are so many variables to consider in the design of a low velocity cyclone system, no attempt was made to break it down into component parts. Each system is made for one particular set of conditions and the cost is based on the work necessary to install such a system. Usually the system is designed and hand-made to fit the job. Installed prices as reported by teachers throughout the state ranged from $1700 for six machines exhausted to $3000 for eleven machines exhausted. If a low velocity unit will meet the requirements of the shop, local sheet-metal shops should be contacted for estimates.

ROTOCLONE system

No attempt was made to break down the cost as each installation is unique. Instructors who have Rotoclones installed to exhaust all machines report the cost is approximately $5000 per installation.

General Collector Recommendations

Based on observations, experiments, research in the library, and conversations with operators of dust-collecting systems, the following recommendations are submitted:

1. That the first requirement to be decided is the purpose of the collecting system. If the objective is to remove dust for the sake of health, then the total cost will be much lower than if the removal is for convenience in housekeeping, in which case all dust,

shavings, etc., are removed through the system.

2. That schools with limited budgets experiment with the air filter system as a means of keeping the dust concentration in the air at a low level.

3. That instructors having small shops investigate thoroughly the possibilities of the small, individual machine collectors. One unit assigned to the two dustiest machines plus another collector piped to several of the less offensive machines would give good coverage at a nominal cost. Not only is the initial cost low but the savings in operational costs would be considerable over a period of years. When a large central unit is installed the large motor and fan must be run to exhaust the waste from even the smallest machine.

4. That a self-contained, high-velocity cyclone collector and separator unit would appear to be adaptable to a majority of the shops of the state. There is a size to fit almost every need. Most of the work of assembling these units can be done by the average instructor, if he has had basic sheet-metal work. Service wise, these units are excellent; noise and cost are troublesome factors. If the separator unit is located in a separate room or is installed with a sound-insulated cover, the noise factor would be greatly diminished. With dust bags in place, these separators also return

the air to the building, eliminating the extra cost of heating.

5. That instructors thoroughly survey the field of available control systems before making a final choice.

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Based on information gathered in this study, these conclusions are presented:

1. That industrial arts teachers are very interested in the control of dust in the woodworking shop.
2. That the health factor is the primary reason teachers are interested in the dust problem.
3. That dust produced in the average woodworking shop is not as detrimental to the lungs as some instructors may believe.
4. That increasing sensitivity to dust with prolonged exposure is the primary health problem. This leads to allergy reactions.
5. That some teachers come to the teaching field with a natural sensitivity to dust.
6. That teachers could alleviate their problem to some extent by use of such simple aids as sweeping compound.
7. That length of time in the dusty shop and the number of students in the classes both have a direct bearing on the desire of the teacher to remain (or not)

in the woodworking field.

8. That the larger schools or administrative units have done the most to control the dust situation.
9. That the atmosphere filter is an inexpensive and practical method of controlling airborne dust in the shop.
10. That the TORIT high-velocity cyclone system is the most practical for the small shop with limited funds.

Recommendations

That further research be done on the dust problem and the effect of dust on the health of the teacher in the woodworking shop. It is the belief of the author that many teachers are leaving the field of woodworking each year due to dust sensitivity. During the course of this study many teachers were questioned who had recently gone into other fields of teaching or were seriously considering switching to such instructional areas as mechanical drawing or metal work.

School boards and administrators should be shown by statistics how they may be losing trained personnel as a result of excessive dust. Such statistics could be used to justify the purchase of an adequate dust control system.

Another field for research is pre-training screening of teaching candidates to determine if their degree of sensitivity to dust would prevent them from working full time in the woodshop. This information would save time, money and inconvenience for the student and the school district that hires him.

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