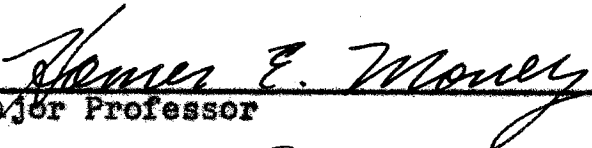
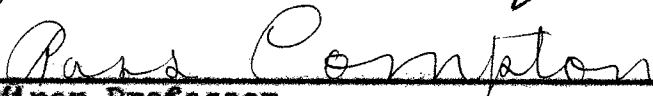


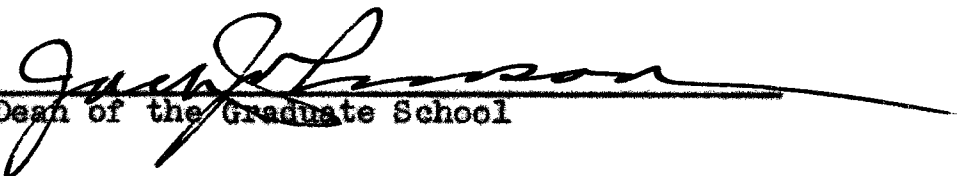
A STUDY AND EVALUATION OF THE LIGHTING IN THE INDUSTRIAL
ARTS SHOPS OF THE FORT WORTH PUBLIC SCHOOLS

APPROVED:


Major Professor


Minor Professor

S. A. Blackburn
Director of the Department of Industrial
Arts


Dean of the Graduate School

A STUDY AND EVALUATION OF THE LIGHTING IN THE INDUSTRIAL
ARTS SHOPS OF THE FORT WORTH PUBLIC SCHOOLS

THESIS

Presented to the Graduate Council of the
North Texas State College in Partial
Fulfillment of the Requirements

For the Degree of

MASTER OF SCIENCE

By
185202

Marvin D. King, B. S.

Fort Worth, Texas

February, 1951

TABLE OF CONTENTS

	Page
LIST OF TABLES	iv
LIST OF ILLUSTRATIONS	v
Chapter	
I. INTRODUCTION	1
Statement of the Problem	
Definition of Terms	
Limitation of the Problem	
Source of Data	
Treatment of the Data	
Related Studies	
II. CRITERIA FOR MEASURING LIGHT	10
Shop Location	
Ratio of Width to Length	
Accepted Standards of Lighting	
Sources of Light	
III. PRESENTATION OF THE DATA	33
IV. ANALYSIS OF THE DATA	60
V. SUMMARY, CONCLUSIONS, AND RECOM- MENDATIONS	69
APPENDIX	73
BIBLIOGRAPHY	106

LIST OF TABLES

Table	Page
1. Schools with a Minimum Amount of Operating Foot-Candles of General Illumination on the Work	63
2. Schools not Reaching Recommended Practices Set up by the Illumination Engineering Society in 1947.	64
3. Shoprooms in the Fort Worth School System Having Uni-Lateral Lighting.	65
4. Number of Shoprooms in the Fort Worth System Having Bi-Lateral Lighting.	66
5. Number of Shoprooms with Multi-Lateral Lighting in the Fort Worth System.	67

LIST OF ILLUSTRATIONS

Figure	Page
1. Ernest Parker Junior High School	82
2. W. P. McLean Junior High School.	83
3. Rosemont Junior High School	84
4. E. M. Daggett Junior High School	85
5. William James Junior High Wood and Metal Shop	86
6. Meadowbrook Junior High School.	87
7. W. C. Stripling Junior High School	88
8. W. C. Stripling Junior High School.	89
9. J. P. Elder Junior High School	90
10. Riverside Junior High School Woodshop	91
11. Riverside Junior High School Metal Shop.	92
12. Paschal High School Woodwork Shop	93
13. Paschal High School Metal Shop	94
14. Paschal High School Drafting Room	95
15. Northside High School Metal Shop	96
16. Northside High School Woodshop	96
17. Northside High School Drafting Room	97
18. Polytechnic Wood, Metal, and Drafting	98
19. Riverside High School Wood and Metal Shop	99
20. Riverside High School Drafting Room	100
21. Diamond Hill General Shop	101
22. Arlington Heights High School Wood and Metal Shop	102

Figure	Page
23. Arlington Heights High School Draft- ing Room	103
24. Handley High School	104

CHAPTER I

INTRODUCTION

The attitude of educators and school executives concerning the lighting conditions in the school shops of this country has undergone a significant change in the last few years. Educators now appreciate the importance of good visual environment for their students and realize that the vast majority of the shoprooms are inadequate in this respect.

In recent years many studies have been made in regard to the proper lighting of school shops. It has been found that very few shops are located so that a sufficient amount of daylight can be provided in all parts of the shop. Therefore, it becomes necessary for the shops to be illuminated with artificial light.¹ Tests show that the more exacting the eye task, the more illumination must be supplied. Illumination values should be higher in shoprooms than in regular classrooms because of the more exacting work done.

The cost of educating a pupil varies considerably in different localities. If the correct type of illumination

¹Gordon O. Wilber, Industrial Arts in General Education, pp. 288-289.

is used, the cost is less than it would be with incorrect illumination. Good illumination is an important factor in preventing eye fatigue and in developing desirable physiological and psychological results.² ✓

There are many factors to be considered when studying the lighting of industrial arts shops. Adequate light is one of the most important factors, and by adequate lighting is meant light that is sufficient in quantity and quality. Other factors to be considered include the location of the shops in the building, the windows, interior painting, width, and length, and the ceiling height of the shoprooms.

The study herein is directed toward better lighting in the industrial arts shops for more efficient work. Efficiency, comfort, and the welfare of a worker are dependent on his eyes.

Statement of the Problem

The study is an evaluation of the light in the industrial arts shops of the public schools of Fort Worth, Texas.

Limitation of the Problem

This study is limited to the industrial arts shops of the junior and senior high schools of Fort Worth, Texas. Only schools for whites are included. This study includes

the woodworking shops, the metal shops, the drafting rooms in the senior high schools, and the general shoprooms of the junior high schools which consist of woodworking, metal working, and drawing in the same rooms.

Definition of Terms

It is very easy to confuse some lighting terms with other terms; therefore, it is necessary to draw lines of distinction between certain terms. The following terms will be used throughout the study:

Proportion.--The ratio of width to length.

Artificial light.--Light from an artificial source of energy.

Natural light.--A light that is opposed to artificial light and comes from daylight.

Direct lighting.--A system of lighting in which practically all of the light comes directly from the light source.³

Indirect lighting.--A system of lighting in which practically all of the light reaching the working area is reflected from the ceiling, walls, or other objects.⁴

Semi-direct lighting.--A system in which the greater part of the light, on a horizontal working plane, comes

³ Elroy W. Bollinger, "Securing the Right Kind of Light," Industrial Arts and Vocational Education, XX (March, 1933), 22.

⁴ Ibid., p. 136.

directly from the lighting unit, and a substantial part comes by reflection from the inner surface of the room.⁵

✓ Semi-indirect lighting.--Provides light directly from the luminaires to the working plane, the greater part of the illumination is produced by light reflected from the interior surfaces of the room.⁶

✓ Glare.--A brightness within the field of vision that will cause annoyance, eye fatigue, or interferes with vision.⁷

✓ Brightness.--Light remitted or reflected from a surface measured in terms of candle power per square inch.⁸

✓ Foot-candles.--A unit or quantity of light falling upon a surface one foot square and at a distance of one foot from a standard light.⁹

Reflected factor.--The ratio of light reflected from a surface to the light falling upon it, usually quoted as the per cent of light reflected as measured in foot-candles.¹⁰

⁵
Ibid., p. 136.

⁶
Ibid., p. 136.

⁷
Charles Bursch and Charles Gibson, "Daylighting the School Plant," American School and University, XVII (1945), 77.

⁸
Ibid., p. 77.

⁹
Bursch and Gibson, op. cit., p. 77.

¹⁰
Ibid., p. 77.

✓ Bi-lateral light.--Light coming from opposite sides of a room.¹¹

✓ Uni-lateral light.--Light coming from one side of a room.¹²

✓ Light.--The raw, visible radiant energy from any light source.¹³

Distribution.--The general "spread" of light over any given area.¹⁴

Foot-candle meter.--An instrument used to measure foot-candles for either natural or artificial light.

Brightness meter.--An instrument used to measure brightness of either natural or artificial light.

Source of Data

Data for this study were obtained from magazines, books, and articles in volumes of The American School and Universities, volumes of The Illuminating Engineering Society, and volumes of The Electric World. Additional information was secured by the use of check sheets and actual measurements obtained by using measuring meters secured from the Texas Power and Light Company in Fort Worth, Texas.

¹¹
Ibid., p. 77.

¹²
Ibid., p. 78.

¹³
Ibid., p. 78.

¹⁴
Ibid., p. 78.

Related Studies

Very few studies have been made in Texas in regard to the lighting situations that exist in the industrial arts shops. Until recently very little thought was given to the type of lighting that should be used for industrial work to obtain the best results.

In recent years, numerous studies have been made in regard to the lighting of shoprooms, but many of the studies have been of the laboratory type. It appears that too little research has been done by independent agencies, and that too little faith has been placed in the theory of a single cause-and-effect, direct relationship between illuminating conditions and pupil reaction. Too little attention has been given the human factors involved.¹⁵

One of the research agencies, after a thorough study of illumination in several different school shops, gave the following report:

There is an urgent need for a broad, comprehensive investigation of all phases of classroom lighting by a national body such as the American Educational Research Association. Financing should be adequate for a long period survey in which there should be unlimited opportunity for studying the physiological, psychological, and educational aspects of the problems. Public Health officials, general medical practitioners, sociologists,

15

Don L. Essex, "Lighting for School Buildings,"
American Schools and Universities, XX, 127.

school plant specialists, illuminating engineers--all should have a hand in the study.¹⁶

The most prolific experimenter and writer in the field of school lighting is Matthew Lucheish, Director of the Lighting Research Laboratory, General Electric Company, Nela Park, Cleveland, Ohio. Lucheish has written several books dealing with school lighting. One of his latest books, Light, Vision, and Seeing, deals entirely with schoolroom lighting and its effects upon child progress.¹⁷

A new researcher in the field of school lighting is Darell Boyd Harmon of the Texas State Department of Health. He has recently experimented with improved classroom lighting involving (a) redecoration; (b) changed patterns of ceilings; (c) controls at the windows. After a six-months period, the following improvements in the health of the pupils involved were found:

1. Reduction of 57.1 per cent in refractive eye problems.
2. Reduction of 90.1 per cent in non-refraction eye problems.
3. Reduction of 44.5 per cent in nutrition problems.
4. Reduction of 30.9 per cent in chronic infection problems (eye, nose, and throat).¹⁸

In 1924 The Western Electric Company in connection with The National Academy of Science began a research that lasted two and one-half years. Its purpose was to study the relation of quality and quantity of illumination in regard to

¹⁶
Ibid., p. 127.

¹⁷
Ibid., p. 127.

¹⁸
Ibid., p. 127.

efficiency. F. J. Roethlisberger and William J. Dickson were in charge of this research. They found, by increasing illumination from twenty-four foot-candles to seventy foot-candles at every work place, efficiency of the workers and students increased. This increase in foot-candles gave an over-all constant illumination of twenty-eight foot-candles in the room.¹⁹

In 1948 the American Standard Practice Committee for School Lighting set up some recommended standards as a result of their research work. These are as follows:

Reflection Factors

Recommended limits		Observed
Ceiling	80-85 foot-candles	85 foot-candles
Walls	50-70 foot-candles	60-70 foot-candles
Trim	30-40 foot-candles	48 foot-candles
Bench tops	35-50 foot-candles	42 foot-candles
Floor	15-30 foot-candles	22 foot-candles

Brightness Ratio

Recommended limits		Observed
The seeing task	1 to 1-3	1-16
Central vision	1 to 1-10	1 to 1-9
Bright surface	1 to 0-10	1 to 2.8
Between luminaires or windows	20 to 1	3.4 to 1 ²⁰

In their research work the members of the committee found that very little work could be done toward efficiency if the standards were lower than the ones given above. The

¹⁹

¹⁹ Ibid., p. 127.

²⁰

²⁰ Russell C. Putman, "The American Standard Practice for School Lighting," American Schools and Universities, XXI, 289.

only way these standards could be met was by increasing the number of luminaires in the rooms of old buildings or by adding a sufficient number of luminaires in new buildings when under construction.

Treatment of the Data

Chapter I of this thesis includes the introduction, statement of the problem, definition of terms, source of data, related studies, and treatment of the data.

Chapter II takes up the factors affecting lighting and the development of the criteria. In this chapter the location of the shops in the building is discussed, the ratio of width and length, how light is measured, the accepted standards of shop lighting, and the sources of light are also discussed.

In Chapter III the presentation of the data is set forth by drawing the plan of the shoprooms, the metal shops, and the drafting rooms. This shows the present type of lights in the rooms, the size of the rooms and the window locations.

Chapter IV is an analysis of the data. Recommended practices are given and compared to the present situations that are found in the schools of Fort Worth.

Chapter V summarizes the findings and gives conclusions. Recommendations are made in such schools that need better light for the shops in the Fort Worth public schools.

CHAPTER II

FACTORS AFFECTING LIGHTING AND THE DEVELOPING OF THE CRITERIA

The purpose of this chapter is to present data from various sources relative to the type of lighting that is recommended by school planning boards for industrial arts shops. Modern practices now are to have rooms lighted from concealed sources to make the proceedings clearly visible in all parts of the rooms. Better lighting in the school is one of the architect's most important problems for it means easier work for the eyes of students and teachers, safer conditions for eyes, nerves and body, more thorough assimilation of knowledge, more efficient and effective education, and a more up-to-date school.

In the study of lighting it is important to know what types of light are the best to bring about the best working conditions. It is also important to know how light is distributed so there will not be any eyestrain, eye fatigue,¹ or discomfort in any manner to the worker.

¹ William E. Warner, "Studies in School Shop Planning," Industrial Arts and Vocational Education, XXIII (February, 1934), 32.

Location of the Shop

There are many differences of opinion in regard to the best location of an industrial arts shop in the school building. Generally, the shoprooms are found in the basement of the building or on the ground floor of the building. Some builders who plan the shoprooms give very little thought to the location of the shops in regard to lighting. Usually, their idea is to place the shop as far away from the main school plant as possible in order to avoid the noise and dust that comes from the shop, especially where wood and metal classes are held.

Regardless of where the shop is located, there are two main factors which should be considered. These factors are very important in regard to shop lighting. William E. Warner gives the thought for one of the factors as follows:

Floor level.--One factor is the first floor or street floor level (the rule usually followed is to place the shop floor one step above the grade level); or the partial basement, second floor for drawing rooms, total basement with area ways, and total basement with area ways (considered least desirable).²

R. W. Sexton presents the thought for the second factor as follows:

²
Ibid., p. 32.

Orientation.--(Direction of face of shop). Orientation is one of the most important phases of shop planning. The shop should be planned to admit as much natural light as possible; however, windows should not be located in such positions as to create direct or indirect glare. If natural light is not sufficient to light the shoproom, artificial light must be added as necessary with the nearest correct diffusion and brightness that can possibly be produced to obtain the result desired.³

Warner's point of view on orientation is as follows:

Drawing teachers have agreed for a number of years on the principle that their rooms should have north light. This custom is seen to be no longer valid if one will go into the problem of natural versus artificial light. There are very few places where natural light is to be depended upon at all times of the year for drawing. Artificial light is infinitely more desirable because it can be controlled equally well at all periods of the day and all seasons of the year.⁴

In regard to shop location, one soon concludes that it does not make any difference which way a shop or drawing room faces as long as the artificial lighting installations are correct. The custom, however, is to have a corner room, a bi-lateral room or a basement room which is least desirable.⁵

³R. W. Sexton, Schools, p. 8.

⁴William E. Warner, "Studies in School Shop Planning," Industrial Arts and Vocational Education, XXIII (February, 1934), 32.

⁵Ibid., p. 33.

Ratio of Width to Length

The width, length, ceiling height, and shape of the shop have a very important place in shop lighting. The general rule followed is to keep shops within a ratio of 1:1 up to 1:2 as regards width to length. Very few shoprooms are found to have a ratio of 1:1; however, drawing rooms can be of this ratio, depending upon the size of the buildings in which they are situated. There are many different shapes for shops, for example E, H, U, or L. There seems to be little excuse for anything other than an oblong shaped shoproom unless the irregularities are used for auxiliary purposes.

A majority of the woodworking and metalworking shops are built to a ratio of 1:2; that is, if the width is twenty-eight feet, the length is fifty-six feet. This gives sixty-two square feet per pupil for a class of twenty-five. It also gives a sufficient amount of space for at least twelve work benches, and an equal distribution of both natural light and artificial light can be obtained, depending considerably upon the spacing of the windows and the location of the installations.⁶

If a shop has a ratio of 1:2, a uniform spacing arrangement for lighting fixtures would be the placing of fixtures

⁶
Ibid., p. 33.

on approximately a ten-foot six-inch center. The distance from the lights to the wall should be at least one half the distance between the fixtures. Occasionally the spacing of fixtures in the shoproom with a bayed ceiling must be adapted to the arrangement and size of the bay.⁷

The height of the ceiling is another important factor in shop lighting. The architect may balk at providing more ceiling height for shops; but it has been found that shops require more ceiling height than is required in academic classrooms because, as a general rule, the windows of the shops are designed to be built higher and nearer the ceilings and because the higher the windows the more natural light comes into the shop and less glare will be upon the students' work. The average ceiling height for the shop is from thirteen to fifteen feet; any height less or greater than this would seem abnormal; however, there are exceptions to the ceiling height in shops where foundry and plumbing are taught. Ceilings of two-story heights are more desirable for these courses.⁸

Planning Installations

Accurate planning of lighting installation is a highly technical procedure and requires much ground work in the

⁷
Ibid., p. 33.

⁸
Ibid., p. 33.

principles of illumination. There are several factors that are to be considered in planning the lighting of the shop. Elroy Bollinger states five of these factors as follows:

1. Determine the number of foot-candles required.
2. Determine the condition factors of the interior (this concerns the color of paint on the walls, ceiling, and equipment), whether favorable, average, or unfavorable.
3. Determine the type of equipment used, such as benches, machines, and supplies.
4. Decide mounting height, considering minimum drop from ceiling. Twelve feet is a desirable mounting height from the floor.
5. Determine lamp size and types of lamps to be used in the actual layout.⁹

Vital things to be understood in planning the installation of lighting equipment are intensity, diffusion, and control. Whether the source be natural or artificial, the most important thing is to secure approximately fifteen foot-candles of light at bench height all over the shoproom. The intensity should increase to at least twenty-five foot-candles in areas where planning, drafting, or fine work is under way.¹⁰

When planning the lighting installation of the shop, the color of the walls and the ceiling should also be considered. The surface should be painted a color to diffuse and absorb

⁹ Elroy W. Bollinger, "Securing the Right Kind of Light," Industrial Arts and Vocational Education, XXII (March, 1932), 137.

¹⁰ Ibid., p. 137.

the light rather than to reflect the full brightness of the source. Ivory paint has been found to be approximately seventy-one per cent efficient in reflection.¹¹ It is best to have above the eye level, including the ceiling, a light color, and below eye level a somewhat darker shade of the same color; ivory, for example, may be used.

Lighting Design

Standards have been set up and recommended by school planning boards for shops and drafting rooms in regard to the amount of natural light and artificial light that should be available for each shop. The recommendations are for eight to one hundred foot-candles. This includes metal shops, woodworking shops, and drawing rooms. If natural light is not sufficient to light the rooms adequately, artificial light must be added as necessary from the required direction and with the correct diffusion and brightness to produce the results desired.¹²

Since the amount of light, natural and artificial, now used in any shoproom can be measured, there is little, if any, excuse for a poorly lighted room. Meters are used to measure illumination in units called foot-candles. The

¹¹

Ibid., p. 137.

¹²

R. W. Sexton, Schools, p. 8.

problem is to maintain the recommended number of foot-candles of illumination on the tops of the desks located furthest from the windows regardless of the position of the window shades or of the daylight levels near the windows, eliminating glare.¹³

Bollinger in his article, "Securing the Right Kind of Light," speaks of natural light in this manner:

The human eye is capable of adapting itself to immense ranges of light intensities. The midday sun on a clear day produces an intensity of as high as 10,000 foot-candles. In the shade under the same light conditions the intensity still remains close to 1,000 foot-candles. This has been compared as to the intensity of sunlight to 10,000 foot-candles placed one foot from a printed page or to a 30,000 watt lamp placed in close proximity. The eye, from this extreme, quickly adjusts itself to room conditions as low as one foot-candle, 1/10,000 as much as the brightness conditions found in sunlight.¹⁴

School planning boards have set up recommended levels for the school shops. One of the latest recommended levels for industrial arts shops is as follows:¹⁵

Department	Foot-candles	Minimum value
Drafting room	25	15
Forge shop, welding	10	6
Machine shop, rough	10	6
Machine shop, medium	15	10
Machine shop, fine	20	12
Machine shop, extra fine	100	25
Sheet metal shop, miscellaneous	12	8

¹³ Ibid., p. 8.

¹⁴ Bollinger, op. cit., p. 137.

¹⁵ Ibid., p. 137.

Sheet metal, punch press	12	8
Sheet metal, spinning	15	10
Sheet metal, rough	3	2
Sheet metal, medium	8	5
Woodwork, rough	8	5
Sizing, planning, sanding, bench work	12	8
Fine bench and machine work	15	10

Drafting and extra fine machine shop work require more foot-candles than any other of the above rooms or work. The more illumination these rooms have, the less eye strain or eye fatigue the students will have as they work.

All lighting authorities seem to agree that, generally, illumination should be used as extensively as possible. This reduces the number of outlets needed and also the amount of maintenance. Careful planning in lighting design will help take care of this situation.

Planning the installation makes necessary a decision regarding the relationship between two types of lighting in the shop, local and general lighting. Local lighting is that type of lighting employed to illuminate some special spot or working area. General lighting is that type of lighting used for a general purpose and in all of the shop. Where local lights are needed occasionally, they may be handled as a special tool and plugged into outlets that have been conveniently placed in the work area.¹⁶

Sources of Lighting

Lighting systems may be classified under two groups, artificial and natural. The object of both is the same, to provide adequate light, or to light the shoproom, by natural or artificial light. Therefore, it may be considered as one problem.¹⁷ In order to arrive at a standard for adequate lighting in the shoproom, the educator should be familiar with the tasks to which the eyes of the pupils are subjected and also consider the eye-tasks for which the pupils are now being trained for performance in later years.¹⁸

Under natural lighting, factors such as the amount of natural light, placement of windows, types of window glass, window design, and exterior and interior controls are discussed. Under artificial lighting, factors such as direct lighting, indirect lighting, semi-direct lighting, and semi-indirect lighting are considered.

Natural lighting or daylighting is provided naturally and is universally available during much of the time school is in session. Careful and intelligent use of it should be made during this time. There are two important factors encountered in natural lighting as stated by the Illuminating Society. These factors are as follows:

¹⁷ R. W. Sexton, Schools, p. 8.

¹⁸ Ibid., p. 8.

Availability and control. Some natural light is available at all times during the day. It is variable according to the seasons and weather, and its lower value co-incides with the months of the school year. With current practices of fenestration, the distribution of daylight in a room is uneven and falls off rapidly as the distance from the primary windows area increases. Daylight should therefore be carefully controlled in order to provide the best results. ¹⁹

There is very little danger of getting too much natural light into the shoproom, but there is very serious danger of providing too small an amount of properly designed natural light. The best practice calls for certain standards in the location and sizes of windows. This is in regard to spacing the windows for more natural light to enter the shop in such ways that a sufficient amount will be upon the working plane and area. ²⁰ Windows should not be spaced more than eighteen inches apart and should extend to within eighteen inches of the front and back walls. This is recommended so there will be no dark shadows in either place. The headers of the windows should extend as close to the ceiling as possible as this increases the reflecting surfaces of the ceiling and indirectly decreases the dark area around the windows. For a uniform daylight illumination, the top of the glass should

¹⁹

Russell C. Putman, op. cit., p. 270.

²⁰

Mays and Caseberg, School Shop Administration, p. 22.

extend to a height above the floor equal to at least half of the room dimension perpendicular to the window wall. There is a great possibility of possibly harmful features in having low sills, because likely there would be excessive brightness of the sills or of external surfaces to which the eye would be exposed.²¹

There are three general ways of daylighting a school room: unilateral lighting, bilateral lighting, and multi-lateral lighting. In this type of lighting the light comes from the outside through windows that are placed in the building. Unilateral lighting is the type of light that comes from windows that are on one side of the room. To reduce the great variation of illumination found in rooms in which daylight is received from windows placed on one outside wall only, room decorations, which are in accord with lighting recommendations covering reflectances and effective control of light entering the windows, are particularly recommended. This type of lighting often results in great uniformity.²²

Bilateral lighting is that type of lighting which comes from opposite sides of the room. This type of lighting has the advantage of improvement in uniformity of daylight illumination. Precaution must be taken with daylight

²¹ Russell C. Putman, op. cit., p. 271.

²² Ibid., p. 271.

arrangements to prevent direct sunlight or skylight from entering the room at angles near the line of view.²³

Another type of lighting that is being used more now than ever before in school shops is multilateral lighting. This type of lighting is light coming in from three sides of the room. This type of light is found to be satisfactory in large rooms where there can be a greater working area. However, there is a greater danger of glare being caused on really bright days.

Window glass is an important factor in daylighting a shoproom. Clear glass is recommended; however, there is a special window glass that is now being used which diffuses the light rays. This glass is on the market now, but it should be carefully examined in view of the results desired. For daylighting a room uniformly, the glass area should not be less than 16 per cent of the floor area. This is for windows starting at least four feet above the floor level.²⁴

There are times, depending upon the location of the shop, when light should be controlled from the interior and exterior. From the exterior this is done quite often by adding louvers or baffles. Stationary vertical louvers are set at a near right angle to the glass and can be used as a

²³
Ibid., p. 271.

²⁴
Ibid., p. 272.

medium for shielding sky brightness from the line of vision toward the front of the room and for a minimum interference with the admission of light. Baffles may be in the form of roof projections or overhangs. Out-riggers may also be used as shields. When the sun is in the opposite position, the out-riggers may act as reflectors to catch the light at its point of incidence.²⁵

Window shades should be translucent and of highly diffusing light-colored material. Shades should never be hung at the top of the sash unless direct sunlight is a problem considered. The upper part of the windows provides the most light and this is most effective in lighting the farther side of the room. The light admitted at the bottom contributes largely to the near side. Consideration should be given to the installation of two roller shades, raising and lowering from the center of the window.²⁶

If natural light is not sufficient to light the room adequately, artificial light should be added as necessary from the required direction and with correct diffusion and brightness. Shops should never be allowed to have less than twelve foot-candles of daylight coming into them,

²⁵

Ibid., p. 273.

²⁶

Mays and Caseberg, School Shop Administration, p. 26.

especially on the working plane. Drawing rooms should never be allowed to have less than eighteen foot-candles of daylight. If daylight is less than the amount recommended, artificial light should be supplemented. Sometimes it is necessary to turn on artificial light only over areas of the room which are at the greatest distance from the windows.

Planning the illumination of a shop requires consideration of wiring and switch arrangements which will permit the operation of luminaires in a manner to supplement lighting over areas where natural lighting becomes insufficient. The light should be so arranged to supply an even distribution to all parts of the shop.²⁷

Artificial lighting systems may be classified into several different types, depending upon the manner in which light is distributed from the luminaires. The different types of lighting systems used in this study are direct, indirect, semi-direct, and semi-indirect lighting. These classifications apply to luminaires for either filament or fluorescent sources, the latter now being used more in the shops.

The Illuminating Engineering Society lists the percentages of light emitted by the luminaires upward and

²⁷ Putman, op. cit., p. 273.

downward and does not take into consideration the efficiency of the luminaires. In the following chart the percentages are given as follows:²⁸

Classification	Approximate distribution of light emitted	
	Upward	Downward
Direct	0-10 per cent	100-90 per cent
Indirect	90-100 " "	10-0 " "
Semi-direct	10-40 " "	90-60 " "
Semi-indirect	60-90 " "	40-10 " "

The quantity of artificial illumination in a given area depends upon the types of light sources used. The selection of the best types of lighting systems for a particular area should receive careful consideration. Therefore, the types of lighting systems are discussed in the following paragraphs.

Direct lighting is a system wherein practically all of the light on a horizontal working plane, or at least that relied upon in the design, comes directly from the light sources. Reflectors are used generally to cut off the upward rays and deflect them to the working area. This type of light often causes a glare, high brightness, and dark shadows. For some places with high ceilings this type of light is usable, but in shops which have a ceiling of twelve feet, it is less suitable to use.²⁹

²⁸Putman, op. cit., p. 273.

²⁹Clarence W. Dunham, Planning Industrial Structures, p. 60.

Indirect lighting is a system of lighting in which practically all of the light reaching a working plane is reflected from the ceiling, walls, hulls or other objects, none of the lighting units being in view of the worker's eyes. There are no sharp shadows or glare from this type of light. Such systems are especially adapted for offices and drafting rooms, but are also used in all parts of the shops. This type of lighting is very comfortable to the eyes if the building or room in which it is located is light in color and clean. Much of the light is lost, however, if there are large windows in the room.³⁰

Semi-direct lighting is a system in which the greater part of the light on a horizontal working plane comes directly from the lighting units. A substantial part comes by reflection from the inner surfaces of the room or from other objects. This type of lighting produces a more diffused illumination than does the direct type of lighting and can be quite annoying to persons who are working if the globes are too near their field of labor.³¹

The semi-indirect lighting system provides appreciable light directly from the luminaires to the working plane; the greater part of the illumination is produced by light reflected from the interior surfaces of the room and from its

³⁰
Ibid., p. 30.

³¹
Ibid., p. 60.

contents. If the direct lighting is more than approximately 25 per cent of the total and if it is of moderate intensity, this type of lighting would be well adapted to shops and drafting rooms where fine work is done.³²

Measurement of Light

Lighting should be appraised and prescribed in terms of quantity and quality. The quality of light refers to the sources of light such as those which have been mentioned previously. The quantity of light refers to the measurement of light in foot-candles or units of illumination.

The measurement of light intensity in foot-candles has been simplified greatly by the development of foot-candle meters. These meters may be placed in the working planes in numerous places in the shop and the intensity read off directly in terms of foot-candles. Since the foot-candle is a measure of intensity of light at any point, it offers a convenient index by which the amount of light needed may be stated and compared.³³

The General Electric Company's bulletin has this to say on the topic:

³²
Ibid., p. 60.

³³
Elroy W. Bollinger, op. cit., p. 137. ✓

The foot-candle is only a measure of intensity of illumination. It is not a measure of seeing. As an influence upon seeing its value is not fixed, for, other conditions remaining the same, the effectiveness of a foot-candle, as a direct aid for seeing diminishes as the level of illumination increases. To double our ability to see it is necessary to increase the level of illumination many times if other factors are not altered. The effectiveness of an additional foot-candle depends upon three primary factors: 1) the visual difficulty of the work which the eye must perform, 2) the manner in which the additional light is used, and 3) the level of illumination to which it is added. It is also possible to alter the quality, direction, diffusion, and distribution of light with a resulting increase in ability to see in many cases.³⁴

Another method of measuring light is now very commonly used. This is the foot-lambert method. The foot-lambert, as a unit of measuring light reflected from a surface, is rapidly replacing the foot-candle method. A foot-lambert is the most common unit of brightness; it is used to measure the average brightness of a light source, or the average brightness of any reflecting surface. In experiments that have been made, it was found that 100 foot-candles of light falling upon a white piece of paper have a reflection factor of 80 per cent. The paper absorbs 20 per cent of the light and reflects to the eye eighty foot-lamberts.³⁵ Much is being done to develop means of measuring light by foot-lamberts. The change of lighting emphasis to the foot-lambert will help school designers to become more conscious of the quality-lighting factors.

³⁴ Ibid., p. 137.

³⁵ Bursch and Gibson, op. cit., p.77. ✓

Uniformity of illumination and freedom from shadows have been effectively obtained by extensive research study. Well distributed light and shadow-free light, both by-products of a uniformly lighted ceiling, become all the more important in a room where pupil seating arrangements depart from the traditional fixed stations. The modern educational practice requires that every available square foot of room area be used for critical seeing tasks. This makes it imperative that more attention be given to light distribution. It is another way of measuring the intensity of light.³⁶

Another method of measuring light is by light diffusion. The brightness of a lighting unit is measured in candle power per square inch in a certain area. Authorities seem to agree that this should not exceed three candles per square inch and preferably should be less. There is some validity to this figure when one knows that the brightness of the sky rarely exceeds this amount. Brightness of a light source in excess of three candles per square inch becomes a possible source of destructive glare.³⁷

The presence of glare is very common and is a serious fault of lighting. Glare may be designated as any brightness within the field of vision which might cause discomfort, annoyance, and fatigue. There are two common types of glare,

³⁶ Ibid., p. 77.

³⁷ Ibid., p. 77.

direct glare and reflected glare. Direct glare is caused by light which reaches the eye directly from the source of light. One will get this type of glare when looking at a brilliant unshielded incandescent lamp or a bright lighting unit. Reflected glare may occur when bright images of windows or of artificial light sources are reflected into the eye from shiny objects on the walls, ceilings, or working areas.³⁸

There are other terms that are used for measuring light. Some of these terms are as follows: lumen, which is a unit of measure for quantity of light equal to the amount of light from a standard candle falling on an area of one square foot one foot from the source, or with an intensity of one foot-candle. Another is the luminaire, a complete lighting unit or fixture consisting of a light source, together with its globes, reflectors, housing, and supports. The luminaires contain the number of watts that are released upon the working plane. Two other terms commonly used in the measurement of light are co-efficient of utilization and reflector factor. Co-efficient of utilization is the ratio between the light emitted by a light source and the amount reaching the working plane. Reflection

³⁸ Clarence W. Dunham, op. cit., p. 61.

factor is the ratio of light reflected from a surface to the light falling upon it, usually quoted as the per cent of light reflected as measured in foot-candles.³⁹

In determining the methods of measuring light there is one important factor called brightness ratio which should be studied very carefully. Brightness ratio is the ratio of brightness of the seeing task to the brightness of the general surroundings. Some liberty has been taken with this term since it is related to these two conditions: 1) the ratio between the seeing task and the surroundings within the classroom, and 2) the ratio between large areas in the classroom and sky brightness.

Light units, such as a lamp on a drop cord directly in the line of vision should not exceed in brightness one-half per cent per square inch if eye fatigue is to be avoided. The brightness of light sources may be reduced by enclosing them in globes that tend to distribute the brightness over their entire surface. A 200 watt clear bulb emits about 180 per cent, but when enclosed in a twelve-inch white globe, the 180 per cent is distributed over an area of approximately 110 square inches, or one and six-tenths per cent per square inch. This gives a value of distribution of the light well within the limits of safety and will be very suitable for shops if the fixtures are not continually in the line of vision.⁴⁰

Chapter III gives the reader the floor plan of each industrial arts shop in the Fort Worth schools and also the light measurement readings that were made in each. A general description of each shop is set forth so that a clearer picture can be obtained of the shoprooms. This description includes location, size of the shoproom, number of luminaires in the rooms, number of windows and location of windows in the rooms, the color design of the rooms, and the types of artificial lighting in the rooms.

CHAPTER III

PRESENTATION OF THE DATA

The installation of proper and adequate lighting facilities in the shops of the junior and senior high schools has been neglected until recent years. In the past twenty-five years much progress has been made in the improvement of means of illuminating school shops. Modern fluorescent lights have replaced the old carbon-filament bulb. Changes in window structure from narrow windows to large windows have been made in order to let in more natural light.

Many of the shops of the present day use fluorescent lighting which is found to be very desirable. Reduction of the flicker has all but eliminated the dangers of accidents. The early fluorescent lights were a hazard. It is much easier to approach a condition of shadowless white light similar to good daylight than to use any other method now available.¹

In many of the industrial arts shops insufficient lighting is still found. At numerous work places the illumination,

¹ Illuminating Engineering Society, American Recommended Practice of School Lighting (February 17, 1938).

both natural and artificial, ranges from the light of five foot-candles to even less. For any operation, the illumination should be measured on the plane occupied by the work or seeing task, whether it be horizontal or vertical. In the industrial arts shops or laboratories there should be at least fifteen operating foot-candles of general illumination for the best quality of work. In the drafting room there should be at least thirty foot-candles operating because of the type of work done in that room.²

In the Appendix of this study there are twenty-three figures which give lighting plans, specifications and other detailed information about shops and shoprooms in various schools in Fort Worth, Texas.

Figure 1 shows the Ernest Parker Junior High School general shop. This shop was changed from direct incandescent lighting to direct fluorescent in the spring of 1946. The general shoproom in the Ernest Parker Junior High School is located in the southwest corner of the basement of the main building. The room is fifty-four feet in length and twenty-six feet in width, with a ceiling height of twelve feet.

There are eight west windows and four south windows, each containing two thirty-four by thirty-four inch glasses, giving a total of 192.6 square feet of glass area in the

²Ibid.

room. The windows are forty-eight inches from the floor level and extend to within twelve inches of the ceiling. The windows are twenty-four inches apart except in the extreme southwest corner. In this area they are thirty-six inches from the corner.

There are twenty-two fluorescent installations in the room; each installation contains two forty-inch luminaires of forty watts which are suspended from the ceiling twenty-four inches, and the distance from the luminaires to the floor is ten feet. From the luminaires to the tops of the work benches is seven feet and three inches. The luminaires are hung five feet and six inches from each side wall. The center row of luminaires are seven feet six inches from each side row. The length of the room the luminaires are five feet six inches from each end, and the installations are twenty-four inches apart.

The color design of the shop is light ivory for the walls and ceiling; the wainscoating is of a darker ivory, while the trim around the walls, the door sills, and window casings is dark oak. The furniture and cabinets in the room are painted focal green; the tops of the benches are painted gray.

Figure 2 in the Appendix shows the McLean Junior High School general shoproom which is located in the northwest corner of the main school building. The room is thirty feet

wide by fifty-nine feet long and the ceiling height is eleven feet. There are three west windows, five north windows, and four east windows in the room, with a total amount of glass area for natural light in the room of 231 square feet. The windows are forty-two inches from the floor level and extend to within twelve inches of the ceiling. They differ in the amount of space between them, but in general, they are eighteen inches apart.

This shop still uses the incandescent type of lighting; however, the luminaires have been remodeled and stronger bulbs are now being used. There are ten luminaires in the room suspended eighteen inches from the ceiling. The distance from the luminaires to the work bench top level is six feet, ten inches, and from machine level it is six feet, two inches. The luminaires are six feet from the north wall and eight feet from the south wall, and extend to within six feet from each end of the walls.

The color design of the shop is light ivory walls, with a green wainscoating and light ivory ceiling. The trim is light green on both the windows and doors. The base of the furniture is painted focal green with natural finished tops except on the benches used in metal work. These tops are painted gray. The storage cabinets are also painted green. The floor is of concrete and it has been painted gray.

The south side of the shop contains more dark areas than any other place in the shop, especially next to the finishing and storage room. Very little natural light can reach this area at any time of the day.

Figure 3 represents the Rosemont Junior High School shop which is located in the northwest corner of the main building. This shoproom is forty-two feet wide and fifty-eight feet long, and has an eleven-foot ceiling. There are six north windows, six west windows, and four south windows which are six feet, four inches from the floor. All of the windows extend to within six inches of the ceiling., and there is a total glass area of 231 square feet in the room. The windows are evenly spaced except on the south side of the room. These windows are thirty-six inches apart, while the others are only twenty-four inches apart.

There are sixteen incandescent luminaires in the room suspending twelve inches from the ceiling. This shop has the indirect type of lighting and uses 300 watt bulbs. The only dark areas found in the shop are on the east side of the room in the mornings.

The luminaires are hung nine feet from the side walls and extend within twelve feet of each end of the room. There are three rows of luminaires and from the center row to each side row is twelve feet. From the tops of the work benches

to the luminaires is six feet, four inches and from machine level it is five feet, eight inches.

The color design of this room is as follows: walls, pale green; trim, ceiling, and cabinets, pale green; base of furniture except drawing equipment, focal green; drawing equipment, light oak base with natural finished tops; metal bench tops, gray, machines painted a dynamic color as recommended by the Pittsburg Glass Company.

Figure 4 represents the Daggett Junior High School shoproom which is also a general shop. The lighting arrangement in the plan shows it as it exists at the present time. The general shoproom in this school is located in the northwest corner of the basement of the main building and is fifty-three feet long and twenty-seven feet wide, with a ceiling height of nine feet and four inches.

This shoproom has seven north windows; however, only six of the windows are in the working area. There are only three west windows. All windows contain two glasses thirty-six inches by thirty-four inches, which gives a total of 244 square feet of glass area in the room for natural light. The windows are forty-two inches from the floor level and extend within four inches of the ceiling. Two areas covering at least six feet are obstructive to natural light where it is badly needed. One place is in the southwest corner, and the other place is along the north wall.

There are seven direct incandescent luminaires in this shoproom, ranging in size from 150 watts to 300 watts. The six luminaires along the sides of the room are eight feet from each wall and are spaced the length of the room twelve feet apart, leaving an area at the front of the room twelve feet long and twenty-seven feet wide with only one luminaire that is placed in the center. In the store room there are two luminaires spaced eight feet apart.

The color design of this shop is as follows: walls and ceiling, light ivory; wainscoting, darker ivory; door and window trim, light brown; furniture and machines, focal green; tops of benches, natural maple finish; and the floor is wood and is finished light.

Figure 5 presents the adjoining woodwork and metal shoprooms of the William James Junior High School which are located on the east side of the north wing of the main school plant. The width of these rooms is twenty-two feet and the combined length is sixty-seven feet with a ceiling height of twelve feet.

Uni-lateral lighting is found in these shoprooms as natural light comes in from only one side of the room. There are nine east windows giving a total of 302 square feet of glass area for the two rooms. The windows are thirty-six inches above floor level and extend to within six inches of the ceiling.

In the two rooms there are twelve indirect incandescent lights with 200 watt bulbs in each luminaire. These are kept on constantly in the afternoons because of the lack of natural light in the rooms. The luminaires are suspended from the ceiling twelve inches and are spaced approximately seven feet, six inches apart when measuring the width of the room and approximately eight feet, six inches apart when measuring with the length of the rooms.

The color design of these two rooms is similar to other shoprooms in the Fort Worth school system: walls, light ivory; ceiling, white; trim, light oak; and cabinets, light green. In the metal shop the bases of the furniture, green; and the tops, gray. In the woodwork room the benches are all finished in natural color.

Figure 6 shows the floor plan of the Meadowbrook Junior High School general shop. This shoproom is located on the ground floor of the main school plant in the southwest corner. It is twenty-nine feet wide by thirty-eight feet long and has a twelve-foot ceiling.

There are five windows on the west side of the building with seventy-two panes in each window. The south end of the shop contains two windows thirty-two inches wide and forty-two inches high. There is a total amount of 218 square feet of glass area in the room. The windows are thirty inches above floor level and extend to within twenty inches of the

ceiling. They are spaced approximately thirty-four inches apart on the west side and four feet on the south side.

This shop has semi-indirect lighting with each luminaire containing 300 watt bulbs. There are fifteen luminaires in the main shop area and storage spaces suspended twenty-seven inches from the ceiling. The distance from the luminaires to the top of the benches is seven feet. There are three rows of luminaires with four lumens in each row equally spaced from each other and from each side wall and from each end.

The walls, trim, and wainscoating of this room are painted a light green. The ceiling is painted white; doors and door facings are of light oak finish; all benches have green bases with gray tops, and the cabinets within the shop are also painted gray; the floor is a dark concrete.

Figure 7 sets forth the W. C. Stripling woodwork and metal shop. This shoproom is located on the west side of the main building in the basement. The room is twenty-two feet wide and sixty-eight feet long and has a ceiling height of eleven feet.

This room is uni-lateral as natural light can come into the room from only one direction. There are ten large windows on the west side of the room and these give a total of 270 square feet of glass area for natural light to enter into the room. The windows are forty inches from floor level

and extend within six inches of the ceiling. The windows are double and between them is a distance of twenty-eight inches except between the partition at the north end of the room where the distance is forty-eight inches.

There are seven direct incandescent lights in the main shop area and two direct incandescent lights in the storage and finish room, each containing one 200 watt bulb. These are suspended twelve inches from the ceiling and are seven feet, four inches from the top of the work benches. From the south wall of the shop the luminaires are seven feet, six inches and from there on they are spaced approximately eighteen feet from each other. The luminaires are only six feet from each side wall.

The walls and ceiling of this room are finished in light ivory, and the trim and doors are finished in light oak. Five of the woodwork benches are finished with green bases and gray tops and five of them are finished in natural color which is light oak. The metal benches are painted with a green base and gray top.

Figure 8 represents the drawing and electrical room at the W. C. Stripling School which is located in the basement on the east side of the main building. This room is twenty-two feet wide and thirty-eight feet long with a ceiling height of eleven feet.

This room also has uni-lateral lighting as the natural light comes in from only one direction. There is only 105 square feet of glass area in the room. The windows are forty-two inches from the floor level and extend to within six inches of the ceiling. The windows are in pairs and are spaced approximately twenty-eight inches apart; however, there is a distance of sixty inches between the two pairs of windows. From the last pair of windows to the north wall there is a dark area of eleven feet. In the room there are only six direct incandescent luminaires, each containing one 200 watt bulb. These luminaires hang twelve inches from the ceiling and are seven feet, eight inches from the top of the drawing tables.

The walls and the ceiling are painted white and the trim, doors, door facings and window casings are painted dark oak. The base of the electrical tables are painted green with gray tops and the drawing tables are dark walnut.

Figure 9 shows the woodwork and metal shops of the J.P. Elder Junior High School. These are adjoining rooms and are twenty-two feet wide by eighty-eight feet in length with a ceiling height of twelve feet. The rooms are located on the north side of the main building and in the basement.

These rooms also have uni-lateral lighting, as natural light can enter from only one direction. There are eleven windows in the two rooms which give a total of 342 square

feet of glass area. The windows are forty inches above floor level and extend to within six inches of the ceiling. In the wood work shop the windows are spaced in two places five feet apart, but in the metal shop only one space is five feet between the windows. Other windows are spaced only twenty-four inches apart.

In each of the shops there are six luminaires each containing one 200 watt bulb. These lights are suspended twelve inches from the ceiling and are eight feet, four inches from bench top level. The lights are spaced approximately eight feet apart and five feet, six inches from each side wall.

The color scheme consists of light ivory walls, white ceiling, and green storage cabinets. The base of the furniture in the metal shop is painted green and the tops are painted gray. The furniture in the woodwork shop is all finished in natural finish of light oak.

Figure 10 describes the Riverside Junior High School woodwork and drawing room. This is also a new junior high shop and has been in operation only since school opened in the fall of 1950.

The woodwork and drawing department of the Riverside Junior High School shop is located in the extreme south part of the main building in a room forty-two feet long and thirty-four feet wide with a ceiling height of fifteen feet.

There are twelve large windows forty-four inches wide and eight feet high in this shoproom. Eight of these windows are located on the south side of the room and four of them are located on the east end of the room. This gives a total of 352 square feet of glass area for natural light. The windows are fifty-two inches above floor level and forty-eight inches below the ceiling.

Three rows of lights, consisting of four luminaires in each row, run the length of the room. These are approximately eight feet apart and eight feet from each side wall and they are also eight feet from each end of the room. The luminaires hang twenty-eight inches from the ceiling and are of indirect type. The luminaires are thirteen feet from floor level and ten feet, nine inches from the top of the work benches and machine level.

The wainscoting is of red brick to a height of fifty-two inches. The walls from the wainscoting up are painted a very light green, while the ceiling is of a light grayish color. The base of the furniture is painted a dark green with the exception of the tops, which are finished in natural maple. The equipment is of dynamic design.

Figure 11 presents the Riverside Junior High School metal shop which is located in the extreme south part of the main building and adjoins the woodwork and drawing room on the west. This room is forty-two feet long and thirty-four

feet wide with a ceiling height of fifteen feet. There are twelve large windows forty-four inches wide and eight feet high in this shoproom. Eight of these windows are located on the south side of the room and four of them are located on the east end of the room, giving a total of 352 square feet of glass area for natural light. The windows are fifty-two inches above floor level and forty-eight inches below the ceiling.

Three rows of lights, consisting of four luminaires in each row, run the length of the room. These are approximately eight feet apart, eight feet from each side wall, and also eight feet from each end of the room. The luminaires are suspended twenty-eight inches from the ceiling and are of indirect type. The luminaires are thirteen feet from floor level and ten feet, nine inches from the top of the work benches and machine level.

The wainscoating is of red brick to a height of fifty-two inches. The walls from the wainscoating up are painted a very light green; the ceiling is of a light grayish color. The bases of metal work benches are painted green and the tops are painted gray. The equipment is of dynamic design.

Figure 12 represents the woodwork shop of the Paschal High School which is located in the basement of the main building in the southeast corner of the building. The room

is thirty-three feet wide and eighty feet long, with a ceiling height of twelve feet.

This shoproom is bi-laterally lighted as natural light comes in from the east and west. There are five large windows on the east and three large windows on the south, giving a total of 432 square feet of glass area in the room. The height of the windows from floor level is four feet and they extend to within twelve inches of the ceiling. There is no space between the windows except metal framing which separates the glasses. Approximately twenty-five feet of the north end of the shop has no windows at all; approximately twelve feet at the south end of the shop on the east side and also the south end of the shop have no windows. Much of the natural light entering the shop in the afternoon comes from the south, hence the north end of the shop has to depend entirely upon artificial light.

There are three rows of fluorescent lights that run the entire length of the shop. There are two forty watt tubes to each luminaire which are suspended from the ceiling forty-two inches and are five feet from the tops of the benches.

At the time the measuring readings were being taken the shop was being redecorated and all inside trim, walls, and the ceiling were being painted a very light shade of

green. The furniture was painted a focal green on the bases with the tops finished as natural maple.

Figure 13 shows the metal shop at the Paschal High School. This shop is located on the southwest corner of the main building slightly under ground level in a room twenty-two feet and sixty-eight feet wide and long, respectively, with a twelve-foot ceiling.

On the south side of the room are nine large windows, and on the west end is one large window. The windows are forty-six inches from the floor level and extend to within twelve inches of the ceiling, giving a total glass area of 286 square feet. There is no spacing between the windows except the metal frames which hold the glass. Approximately fifteen feet from the west end of the room and the same distance on the west end of the room the glass area stops.

There are sixteen, two-tube, forty-watt fluorescent luminaires located in the room. These hang from the ceiling three feet, six inches and are six feet from the bench top level, five feet, six inches from machine level. These lights are not needed very much except on cloudy days because quite a bit of natural light is available at all times of the day.

This shoproom has been redecorated and is very similar to the finish that was being applied to the woodworking shop. The work benches all have green bases with gray tops.

Figure 14 represents the drafting room at Paschal High School. This room is located on the south side of the main building and slightly under ground level. The room is twenty-two feet wide by forty-eight feet long and has a ceiling height of twelve feet, eight inches.

The south side of the room is completely filled with windows except for one space of five feet in the center of the wall. These windows are thirty-eight inches from floor level and extend to within twelve inches of the ceiling. There is a total of 277 square feet of glass area, and through this area much natural light can enter.

There are thirteen direct fluorescent two-tube, forty watt luminaires in the room. These are suspended thirty-six inches from the ceiling and six feet from the tops of the drafting tables. (There is also one row of luminaires across the front of the room.)

The wainscoating in this room is painted a dark ivory; the walls and ceiling are painted white and the woodwork is stained a light oak. The drafting tables are finished in light oak, natural color with light finished maple tops.

Figure 15 shows the Northside High School metal shop which is located in the northeast corner of the main building. This room is thirty feet wide by forty feet long and has a fourteen-foot ceiling except in the southwest end of

the room where a balcony drops to within seven feet of the floor. This extends out into the room ten feet.

There are six large windows on the northwest side of the building and two small windows in the northeast end of the room. This gives a total of 250 square feet of glass area in the room. The windows on the northwest are forty-two inches from floor level and extend to within twenty-four inches of the ceiling. The small windows are seven feet from floor level and extend to within twenty-four inches of the ceiling.

There are four direct incandescent luminaires in the room and two luminaires under the balcony. Three luminaires in the main working area contain one 500 watt lumen each. The lumens under the balcony are 200 watt. These luminaires suspend from the ceiling approximately twenty-four inches and are nine feet from the tops of the work benches.

The wainscoating in the metal shop is a light green, and the walls and ceiling are white. The work benches have a focal green base with gray tops, and the cabinets are painted a combination of that color.

Figure 16 shows the woodwork shop of the Northside High School. This room is located in the northwest corner of the main building slightly under ground level. The room is twenty-seven feet wide by forty-four feet long and has a ceiling height of fourteen feet.

There are six large windows on the north and three windows on the west, giving a total glass area of 228 square feet in the room for natural light. The windows on the north are forty inches from floor level; the windows on the west are five feet from floor level, and all of them extend to within eighteen inches of the ceiling.

The room has four direct incandescent luminaires in the main working area and two direct incandescent luminaires under the balcony. The luminaires in the main working area contain one 500 watt lumen each and the lumens under the balcony are 200 watt. The luminaires in the working area hang twenty-four inches from the ceiling and are nine feet, four inches from the tops of the benches and machines.

The color design of the room is identical with that of the metal shop.

Figure 17 represents the drafting room in the North side High School. This room is located on the second floor of the west side of the main building and is twenty-two feet wide by thirty feet long with a ceiling height of twelve feet.

There are three pairs of double windows in the west side of the room which gives the room uni-lateral lighting. The double windows are spaced thirty inches apart and are thirty inches from floor level. They extend to

within nine inches of the ceiling and give a total of 170 square feet of glass area for the room.

There are two continuous rows of fluorescent luminaires in the room. They are located at ceiling level and are seven feet, four inches above the tops of the drafting tables.

The color design of the room is as follows: wainscoating, pale green; walls, light green; ceiling, white; trim, door, door facing and window casings, fumed oak; drafting tables and tops and cabinets, light maple finish. The floor is finished in a light natural color.

Figure 18 represents the industrial arts shops of the Polytechnical High School. These shops are located in the corner of the main building. The size of the shop-rooms are as follows: drafting room, eighteen feet wide by forty-eight feet long; metal shop, thirty-four feet wide by forty-eight feet long. The ceiling height of all rooms is fifteen feet except in the woodwork shop where a balcony drops to within seven feet of the floor in the east end of the room for approximately fifteen feet.

In the drafting room there are six north windows and two west windows. These windows are forty-eight inches from floor level and extend to within twelve inches of the ceiling, giving a total of 170 square feet of glass area in the room.

In the metal shop there are three west windows and three large south windows. These windows are four feet from floor level and extend to within twelve inches of the ceiling. There is a total of 270 square feet of glass area in this room.

These shops are equipped with direct and indirect incandescent luminaires. In the metal shop there are also three short rows of direct fluorescent luminaires. The fluorescent luminaires in the metal shop hang seven feet from the ceiling. The incandescent luminaires in the shops are suspended from twelve to thirty inches from the ceiling. In the drafting room the luminaires are eight feet, six inches from the drafting table tops, and in the wood shop they are ten feet, ten inches from the work bench tops. Under fifteen square feet of balcony space in wood shop there are only two incandescent luminaires; one of these is in the room used for an office.

The color design that has been mentioned in the other schools is also used in this school except in the wood shop. In place of wainscoating there is red brick, and the walls are of cream brick.

Figure 19 represents the woodwork and metal shop in the Riverside High School. This shoproom is forty feet wide by forty-nine feet long and has a ceiling height of thirteen feet. This room is an annex to the main building and is on the ground floor.

This shoproom has multi-lateral lighting because natural light can enter from three different sides. At the south end of the building there are three large windows; at the east end there are three pairs of double windows which are spaced twenty-eight inches apart. On the north end of the building there are seven windows, six of them being spaced twenty-four inches apart. The windows are forty-two inches from the floor level and extend to within twenty-four inches of the ceiling. There is a total of 375 square feet of glass area in the room.

The room has fifteen direct incandescent luminaires, each containing one 300 watt bulb and suspended from the ceiling thirty inches. The luminaires are eight feet from the bench top level and seven feet, six inches from machine top level. The luminaires in the finishing room are suspended from the ceiling approximately six feet to give better light for finishing purposes.

The color design is as follows: wainscoating, light green; walls, ivory; ceiling, light gray; cabinets, doors, door facings, and window facings, light green; benches, bases green with gray tops; and floor, dark concrete.

Figure 20 represents the drafting room in the Riverside High School. This room is located in the east side of the north wing of the main building. The room is twenty-four feet wide by thirty-four feet long and has a ceiling height of eleven feet.

Four large windows spaced eighteen inches apart are on the east side of the room. This gives a total of 140 square feet of glass area in the room. The windows are thirty-six inches above floor level and extend to within twelve inches of the ceiling.

There are six indirect incandescent luminaires in the room, each containing one 300 watt lumen. These luminaires are suspended from the ceiling twelve inches, giving a distance of six feet, eight inches between them and the drafting table tops.

The color design of the room is as follows: walls, cream; ceiling, light ivory; doors, windows, and trim, light walnut; furniture, tables and table tops, light maple finish; and floor, natural finished pine.

Figure 21 presents the Diamond Hill Junior and Senior High School general shop which is located in the southwest corner of the main building. It is twenty-one feet wide and fifty feet long with a ceiling height of nine feet, six inches.

This shoproom has bi-lateral lighting as natural light can come in from two directions. There are ten windows on the west side of the shop and three windows in the south end of the shop. The windows are spaced twenty-eight inches apart except in one area where the spacing is seven feet, three inches long. The total amount of glass area in the room

is 230 square feet. The windows are forty-two inches from floor level and extend to within six inches of the ceiling.

Eighteen direct fluorescent luminaires are located in the room. Each luminaire contains two tubes of forty watts. One direct incandescent luminaire is located in the finish room. These luminaires are suspended fifteen inches from the ceiling and are five feet, seven inches from the top of the work benches.

The color design of the room is as follows: wainscoting, focal green; walls, light ivory, ceiling, white; trim, doors, door facings and window casing, dark walnut; cabinets, and bases of furniture, green, tops of work benches, finished in natural color of light oak. The floor is of pine and is finished in a light color.

Figure 22 shows the wood and metal shop of the Arlington Heights High School. This room is located in the southwest corner of the main building in a room thirty-two feet wide and forty-one feet long with a twelve-foot ceiling.

Natural light can enter the room from two directions as there are five large windows on the south and five large ones on the west. There is a total of 220 square feet of glass area. The windows are thirty-two inches above the floor level and extend to within eighteen inches of the ceiling.

There are eight direct incandescent luminaires and three direct fluorescent luminaires in the main shop area. The incandescent luminaires are suspended twelve inches from the

ceiling and the fluorescent luminaires are suspended thirty-two inches from the ceiling. Each of the incandescent luminaires contains one 500 watt bulb and the fluorescent lumens are forty watts each. There are five incandescent lights located in the storage, tool and finishing rooms.

The color design of the shoproom is as follows: wainscoating, light green; walls, light ivory; ceiling, light ivory; doors and trim, light green; bases of work benches and tables and cabinets, green; top of work benches and tables, gray.

Figure 23 represents the drafting room of the Arlington Heights High School. The room is an annex to the main building and is situated on the south side of the main building. It is twenty-two feet wide and thirty feet long with a ceiling height of ten feet, six inches.

There are four large windows in the west side of the room giving a total of 100 square feet of glass area. The windows are forty inches above floor level and extend to within twelve inches of the ceiling. The windows are spaced thirty inches apart with thirty-six inches of space between the first and last window and the end walls.

There are two continuous rows of fluorescent luminaires in the room. The luminaires are flush with ceiling. There is a space of six feet, two inches from the top of the drafting tables to the luminaires.

The color design of this room is as follows: walls, light green; ceiling, white; door, trim and window casings, rubbed dark green; drafting tables and tops, light maple finish; floor, variegated tile.

Figure 24 represents the Handley High School general shoproom which is located in the south side of the main building and is twenty-four feet wide by seventy-five feet long with a ceiling height of fourteen feet.

There are fifteen windows in the room spaced twelve inches apart with the exception of two places where the spaces are six feet. The windows are forty-four inches from floor level and extend to within eight inches of the ceiling. There is a total of 280 square feet of glass area in the room.

This room has a peculiar arrangement of lighting. There are twenty-two luminaires in the working area. Eight of the luminaires are on the south side of the room and sixteen of them are on the north side of the room. These luminaires are spaced three feet apart. Six of the luminaires are suspended from the ceiling thirty inches; the remaining luminaires hang eight inches from the ceiling. The floor plan of this room will have to be referred to in order to understand the arrangement.

The color design of the room is as follows: wainscoting, light gray; walls, light ivory; ceiling, light gray; doors and trim, dark walnut; benches, tables, and cabinets, green with gray tops.

In all of the woodwork and metal shops all of the machines and equipment are painted a dynamic design as recommended by the Pittsburg Paint Company. The dynamic color design is as follows: bases of tables and work benches are painted green; tops of tables and work benches are painted gray; bases of machines are painted green; all movable parts of the machines are painted yellow; all stationary parts such as tailstocks on the lathes are painted a light cream, and the vises are painted black. The painting of tools and toolboards is left to the shop instructors.

CHAPTER IV

ANALYSIS OF THE DATA

Data for this chapter were obtained by visiting each school and taking readings of both natural and artificial light. A check sheet was also used. The following information was used on the check sheet to gather the information needed:

Location of rooms used for shop purposes

Size of rooms used for shop purposes

Color design of room, including color of walls, ceiling equipment, furniture, and floors

Type of artificial illumination used in room

The number of luminaires in rooms used for shop purposes

The distance the luminaires were suspended from the ceiling

The height of the luminaires from floor level, bench top level and machine level

The number of windows in each room used for shop purposes

The size of the windows in the room

The amount of glass area in each room used for shop purposes

The readings of natural light in the room near the windows in the center of the room and furthest from windows

The readings of artificial light in the back, in the center, and on each side of the room.

This information was needed in order to discover if the industrial arts shops in the Fort Worth public school system came within range of the recommended practices set up by the Illuminating Engineering Society and other school planning boards, and to find out if the present situations found in the shoprooms are efficient enough for the students to do their work without eye strain, eye fatigue, or other health injuries.

In 1945 a program was begun to correct the artificial lighting in the industrial arts shops of the Fort Worth schools. The Ernest Parker Junior High School shop, which is fifty-six feet long and twenty-seven feet wide, was used as an experimental area. At that time twenty-two, two-tube, direct type, fluorescent luminaires were suspended thirty inches from the ceiling and nine feet, six inches from the floor level. The walls and ceiling were painted a light ivory instead of dull green as they had been formerly. The ceiling was painted white, in accordance with the recommendations of different school planning boards.

The Texas Electric Service Company made several readings of this room in a period of three months to determine

if other recommendations should be made or if additional lighting should be added. Their checks were made on clear days in the morning, on clear days in the evening, on cloudy days and on partly-cloudy days. At the end of their test period of three months the result showed that there was minimum operating foot-candles of general illumination of 31.3 which was sufficient and no further recommendation would be made.

The Diamond Hill general shop was the next to be changed from incandescent lighting to fluorescent and then came the Paschal High School shops. At the present time, with the exception of the drawing rooms of Northside High School and Arlington Heights High School, and a few installations of the fluorescent type of illumination in the Polytechnic High School metal shop, the remainder of the schools still have incandescent lighting.

Table 1 presents the schools with a minimum amount of operating foot-candles of general illumination.

Five of these schools have fluorescent lighting; the other shops still have incandescent lighting, but are situated in such locations that natural light is available plentifully at all times of the day. There are a few dark places in the shops at all times of the day and most of the shops use artificial illumination in these areas during class periods.

TABLE 1

SCHOOLS WITH A MINIMUM AMOUNT OF OPERATING FOOT-CANDLES
OF GENERAL ILLUMINATION ON THE WORK

Schools	Minimum operating foot-candles of general illumination on work level
Ernest Parker Junior High	31
Rosemont Junior High	29
Meadowbrook Junior High	33
Diamond Hill Senior High	45
Riverside Junior High Wood Shop	51
Riverside Junior High Metal Shop	38
William James Junior High Wood Shop	29 ✓
William James Junior High Metal Shop	32 ✓
W. C. Stripling Wood Shop	27
Handley General Shop	28
J. P. Elder Junior High Wood Shop	27
J. P. Elder Junior High Metal Shop	25
McLean Junior High General Shop	28
Paschal High School Metal Shop	66
Paschal High School Drafting Room	34
Northside High School Drafting Room	65
Northside High School Wood Shop	30
Northside High School Metal Shop	36
Polytechnic High School Drafting Room	45
Polytechnic High School Wood Shop	35
Polytechnic High School Metal Shop	70
Riverside High School Wood and Metal Shop	34
Arlington Heights High School Shop	51

Table 2 reveals the schools which do not meet recommended practices as set up by the Illuminating Engineering Society in their revised addition of 1947.

With the exception of Paschal High School Wood Shop which has fluorescent lighting, these shops have incandescent lighting and are located in such positions where natural light is not available except near the windows at all times of the day. These shops may have plenty of

natural light in the mornings but in the afternoons artificial light has to be depended upon entirely; or, there may be plenty of natural light in the afternoons but in the mornings artificial light has to be depended upon entirely.

TABLE 2

SCHOOLS NOT REACHING RECOMMENDED PRACTICES SET UP BY
THE ILLUMINATION ENGINEERING SOCIETY IN 1947

Schools	Minimum operating foot-candles of general illumination work level
Riverside High School Drafting Room.	27
W. C. Stripling Drafting Room	13
Daggett Junior High	23
Paschal High School Wood Shop	23

The amount of natural light coming into the room depends upon the number of windows in the room and upon the location of these windows. Mullions and piers between windows should be narrow in order to prevent the casting of shadows upon the working areas.

Table 3 presents the number of shops in the Fort Worth public school system which have uni-lateral lighting.

This group of schools represents the uni-lateral type of natural lighting. They range from four windows to fifteen windows in which natural light can act as a source of lighting.

TABLE 3

SHOPROOMS IN THE FORT WORTH SCHOOL SYSTEM
HAVING UNI-LATERAL LIGHTING

Schools	Type of shops	Location	Number of windows
J. P. Elder	Wood shop	North	5
J. P. Elder	Metal "	North	5
William James	Wood "	East	5
William James	Metal "	East	4
W. C. Stripling	General "	West	8
Handley	General "	South	15
Arlington Hts.	Drafting room	West	4
Northside	Drafting room	West	6
Riverside	Drafting room	East	4
Paschal	Drafting room	South	11
Polytechnic	Wood shop	West	6

The group of schools and the number of shoprooms in the Fort Worth public school system having a bi-lateral type of lighting are shown in Table 4 which follows on page 66 of this study.

TABLE 4

NUMBER OF SHOPROOMS IN THE FORT WORTH SYSTEM
HAVING BI-LATERAL LIGHTING

School	Type of shop	Location of windows	Number	Location of windows	Number
Parker	General	West	8	South	4
Diamond Hill	General	West	9	South	3
Daggett	General	West	2	North	6
Meadowbrook	General	West	5	South	2
Riverside	Wood	East	4	South	8
Riverside	Metal	West	4	South	8
Arlington Hts.	Wood & metal	West	5	South	6
Northside	Wood	West	3	North	6
Northside	Metal	North	6	East	3
Paschal	Wood	East	8	South	3
Paschal	Metal	South	8	West	1
Polytechnic	Drafting	North	6	West	2
Polytechnic	Metal	West	3	South	3

The windows of these shops are not located on opposite sides of the rooms but on one side and on one end of each room. According to some specialists in the field of lighting, this type of room is classified as bi-lateral.

Table 5 sets forth the number of school shops in the Fort Worth system with multi-lateral lighting.

TABLE 5
NUMBER OF SHOPROOMS WITH MULTI-LATERAL LIGHTING
IN THE FORT WORTH SYSTEM

School	Type of shop	Location of windows	Number	Location of windows	Number	Location of windows	Number
Rosemont	General	South	3	East	6	North	6
Riverside	Wood & Metal	South	3	East	6	North	6
McLean	General	North	7	West	2	East	4

The natural light that enters a room from three different sides of the room classifies these schools as having multi-lateral lighting.

Shades that are raised and lowered from the center of the windows are used in almost all of the shops, especially if they are located where extreme brightness is found to

exist. There are some shops which do not have shades at all but a diffusing type of glass is used that reflects a great amount of the sunlight and keeps down glare.

Light-colored surfaces are found in most of the shop rooms. The color scheme found in the majority of the shops consists of a dark ivory wainscoating, with light ivory walls and white ceilings. There are some shops that have a light green wainscoating, light ivory walls, and white ceilings; while other shops have a light pale green wall from the floor up to the ceiling and a light ceiling. This color scheme is found in the Rosemont Junior High School shop, the Paschal woodwork shop, and the Arlington Heights drafting room. These colors are not accepted by the Illuminating Engineering Society because they seem to be more of a drawing card rather than a place with good lighting. Light colors are of particular value in providing a high utilization of light because it reflects a large part of it toward the working area. The ceiling should reflect at least 75 per cent of the light which strikes it, and the walls should reflect from 50 to 60 per cent of the light which strike them. Walls should be tinted a darker color than ceilings because very light walls at the line of vision or below eye level cause annoying brightness.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

During the last five years there has been a program underway to change the lighting systems in the industrial arts shops of the Fort Worth public schools in order to meet the practices set up by the different school planning boards. Many of the shops have already been changed from a poor type of incandescent lighting to a higher type of incandescent lighting or to fluorescent lighting.

Also included in the program of improvement is the redecoration of the shoprooms and drafting rooms so that working conditions may be better. The redecoration program not only included the painting of the walls and ceilings of the seventeen shops included in this study, but it also included the refinishing and painting of the furniture, cabinets, and machines in a dynamic scheme set up by the Pittsburgh Paint Company. The dynamic color scheme does not harm in any manner the reflection of the light, natural or artificial, neither does it cause glare in the working areas. In many instances it keeps down glare, especially where bench tops are in the direct sunlight and there are not any shades to control this situation.

Out of the seventeen schools checked in regard to the lighting, only 4 per cent do not meet the recommended practices set up by the Illuminating Engineering Society in 1947 of from twenty-five to forty foot-candles per room of general illumination for woodworking and metal shops, and from thirty to fifty foot-candles of general illumination for drafting rooms. This is not a high per cent under the conditions which exist in the shops, because the sizes of the luminaires range from 200 watts to 500 watts throwing from four to six lumens over a general area of six feet in diameter in most of the shops.

The lack of good illumination exists more in the finishing rooms and store rooms. Very few of these rooms have natural light coming into them and artificial illumination has to be depended upon entirely.

Most of the machines in the shops are situated in areas where natural light is available at all times of the day. In the majority of the shops natural light can be controlled by shades on the windows if it is causing glare. This causes more dark areas to be in the shops, but due to the location of the rooms, this can not be corrected and calls for more artificial lighting to be used.

Each instructor in the shops stated that artificial lighting was used, regardless of the type of weather, during each class period because there was not enough natural

light in the room to perform the tasks. Some instructors used artificial lighting only in areas where the darker areas exist; others state they have to use artificial light at all times in order to have an adequate amount of illumination.

Conclusions

The industrial arts shops of the Fort Worth school system, even though the majority of them do have a minimum amount of foot-candle of general illumination, have to depend upon artificial lighting too much of the time that they are in operation. The lack of sufficient glass area available in each shop, and the location of the shops where sunlight is absent most of the day are the causes of artificial light being the main source of illumination.

There are several of the shoprooms that have too few luminaires for the amount of space that is to be covered by the artificial light for it to do much good. The bulb wattage in the shops is too small to meet the demand of artificial light that has to be used in dark areas of the shops, especially on cloudy days.

Even though much has been done in the last five years to remedy the poor illumination that has existed and still exists in some shops, the program has been too slow, and several of the shops are lagging in good workmanship. Not enough stress has been laid on this program to make the

shops a safe place at all times of the day so that the best type of work can be carried on unless extra artificial lighting is used.

Recommendations

From the information revealed by the data secured, and the conclusions made, the findings of this study seem to justify the following recommendations:

1. That more stress be placed upon more and better artificial lighting installations,
2. That the luminaires should be placed nearer the working plane if the shop is having to depend upon artificial lighting,
3. That wattage be increased from 200 watts to 500 watts or more in all shops using incandescent lighting,
4. That larger amounts of glass areas be provided in new shops to be built or remodeled in the future,
5. That shrubbery should be removed from close range of the shops or kept trimmed to the extent that it will not interfere with any natural light that is to enter the shops.

APPENDIX

Check Sheet for Woodwork or General Shops

Name of school _____

Location of room used for shop _____

Basement _____

Ground floor _____

Separate building _____

Shape and Size of Room Used for Shop

Rectangular _____ Width _____ Length _____

Irregular rectangular _____ Width _____ Length _____

Square _____ Width _____ Length _____

Ceiling height of shoproom _____

Color Design of Shoproom

Wainscoating _____ Equipment _____

Walls _____ Furniture _____

Ceiling _____ Cabinets _____

Trim _____ Window Trim _____

Doors _____ Floor _____

Type of Illumination in Shoproom

Incandescent

Fluorescent

Direct _____ Direct _____

Indirect _____ Indirect _____

Semi-direct _____ Semi-direct _____

Semi-indirect _____ Semi-indirect _____

Number of luminaires in shoproom _____

Distance suspended from ceiling _____

Height of Luminaires

From floor level _____

From bench top level _____

From machine level _____

Location of Lights and Windows in Shoproom

(Use back of page of diagramming.)

Number of Windows in the Shoproom

North _____ South _____

East _____ West _____

Height of windows from floor level _____

Size of windows in shoproom _____

Distance of top header of windows from ceiling _____

Amount of space between windows _____

Amount of glass area in shoproom _____

Amount of Natural Light in Shoproom

Near window at front of room _____

Near window at center of room _____

Near window at back of room _____

Center of room _____ Farthest from source of natural
light _____

Front center _____ Front of room _____

Center of room _____ Center of room _____

Back center of room _____ Back of room _____

Amount of Artificial Light in Shoproom

All shades down _____ Lights on _____ No shades _____ Lights on _____

Right side of room

Front of room _____

Center of room _____

Back of room _____

Center of room

Front of room _____

Center of room _____

Back of room _____

Left side of room

Front of room _____

Center of room _____

Back of room _____

Check Sheet for Metal Shops

Name of school _____

Location of room used for metal shop _____

Basement _____

Ground floor _____

Separate building _____

Shape and Size of Room Used for Metal Shop

Rectangular _____ Width _____ Length _____

Irregular rectangular _____ Width _____ Length _____

Square _____ Width _____ Length _____

Ceiling height of metal shop _____

Color Design of Metal Shop

Wainscoating _____ Equipment _____

Walls _____ Furniture _____

Ceiling _____ Cabinets _____

Trim _____ Window trim _____

Doors _____ Floor _____

Type of Illumination in Metal Shop

Incandescent

Fluorescent

Direct _____ Direct _____

Indirect _____ Indirect _____

Semi-direct _____ Semi-direct _____

Semi-indirect _____ Semi-indirect _____

Number of luminaires in metal shop_____

Distance suspended from ceiling_____

Height of Luminaires

From floor level_____

From bench top level_____

From machine level_____

Location of Lights and Windows in Metal Shop

(Use back of page for diagramming.)

Number of Windows in Metal Shop

North_____South_____East_____West_____

Height of windows from floor level_____

Size of windows in metal shop_____

Distance of top headers of windows from the ceiling_____

Amount of space between windows_____

Amount of glass area in metal shop_____

Amount of Natural Light in Metal Shop

Near window at front of room_____

Near window at center of room_____

Near window at back of room_____

Center of room

Front center_____Farthest from source of natural
light

Center of room_____Front of room_____

Back center of room_____Center of room_____

Back of room_____

Amount of Artificial Light in Metal Shop

All shades down ___ Lights on ___ No shades ___ Lights on ___

Right side of room

Front of room _____

Center of room _____

Back of room _____

Center of room

Front of room _____

Center of room _____

Back of room _____

Left side of room

Front of room _____

Center of room _____

Back of room _____

Check Sheet for Drafting Room

Name of school _____

Location of drafting room _____

Basement _____ Separate building _____

Ground floor _____ Third floor _____

Second floor _____

Shape and Size of Drafting Room

Square _____ Width _____ Length _____

Rectangular _____ Width _____ Length _____

Irregular rectangular _____ Width _____ Length _____

Ceiling height of drafting room _____

Color Design of Drafting Room

Wainscoating _____ Furniture _____

Walls _____ Cabinets _____

Ceiling _____ Window trim _____

Trim _____ Floor _____

Doors _____

Type of Illumination in Drafting Room

Incandescent

Fluorescent

Direct _____ Direct _____

Indirect _____ Indirect _____

Semi-direct _____ Semi-direct _____

Semi-indirect _____ Semi-indirect _____

Number of luminaires in drafting room _____

Distance suspended from ceiling _____

Height of luminaires

From floor level _____

From tops of drafting tables _____

Location of Lights and Windows in Drafting Room

(Use back of page for diagramming.)

Height of windows from floor level _____

Number of Windows in Drafting Room

North _____ South _____ East _____ West _____

Size of windows in drafting room _____

Distance of top headers of windows from ceiling _____

Amount of space between windows _____

Amount of glass area in drafting room _____

Amount of Natural Light in Drafting Room

Near window at front of room _____

Near window at center of room _____

Near window at back of room _____

Center of room _____ Farthest from source of natural
light

Front center _____ Front of room _____

Center of room _____ Center of room _____

Back of room _____ Back of room _____

Amount of Artificial Light in Drafting Room

All shades down _____ Lights on _____ No shades _____ Lights on _____

Right side of room

Front of room _____

Center of room _____

Back of room _____

Center of room

Front of room _____

Center of room _____

Back of room _____

Left side of room

Front of room _____

Center of room _____

Back of room _____

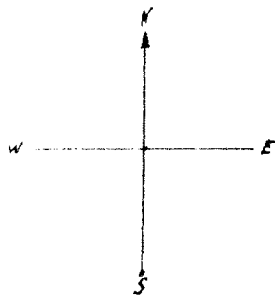
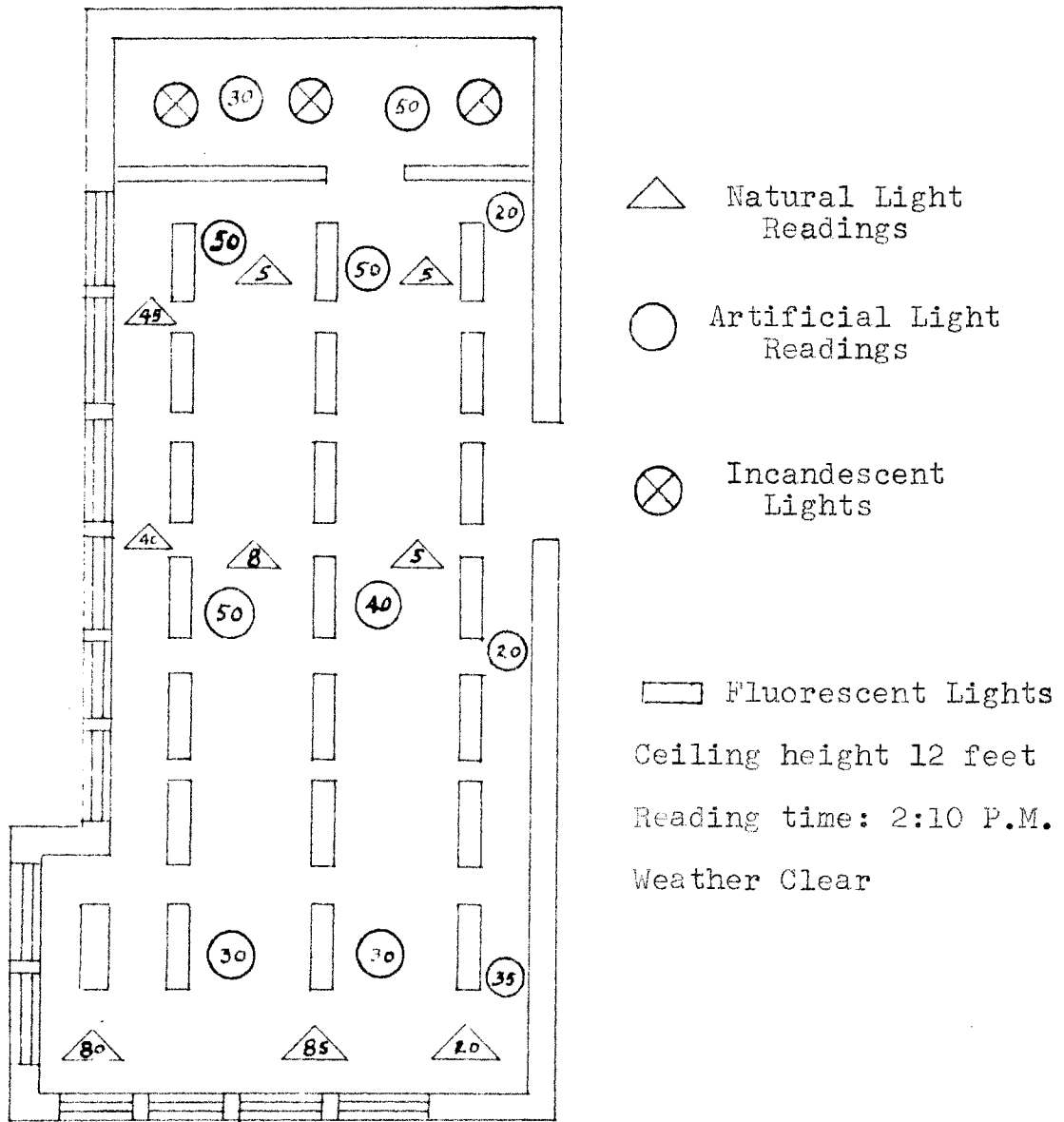
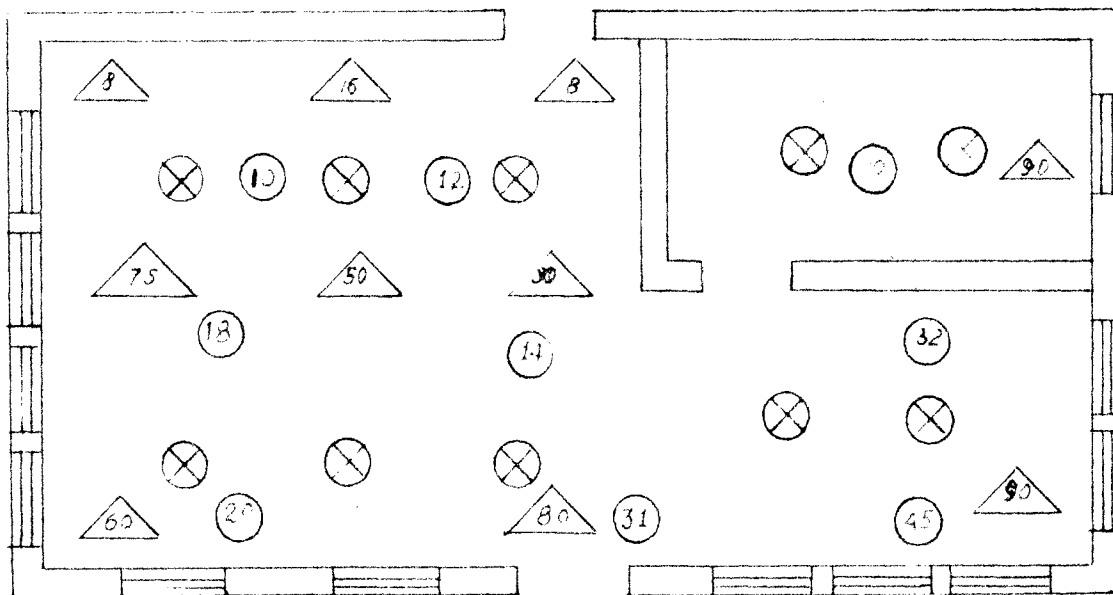


Fig. 1.--Ernest Parker Junior High School General Shop



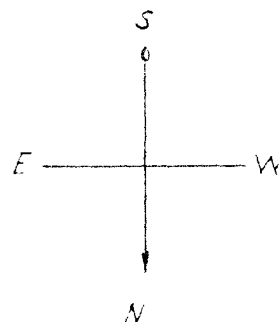
Natural Light Readings



Artificial Light Readings



Incandescent Lighting

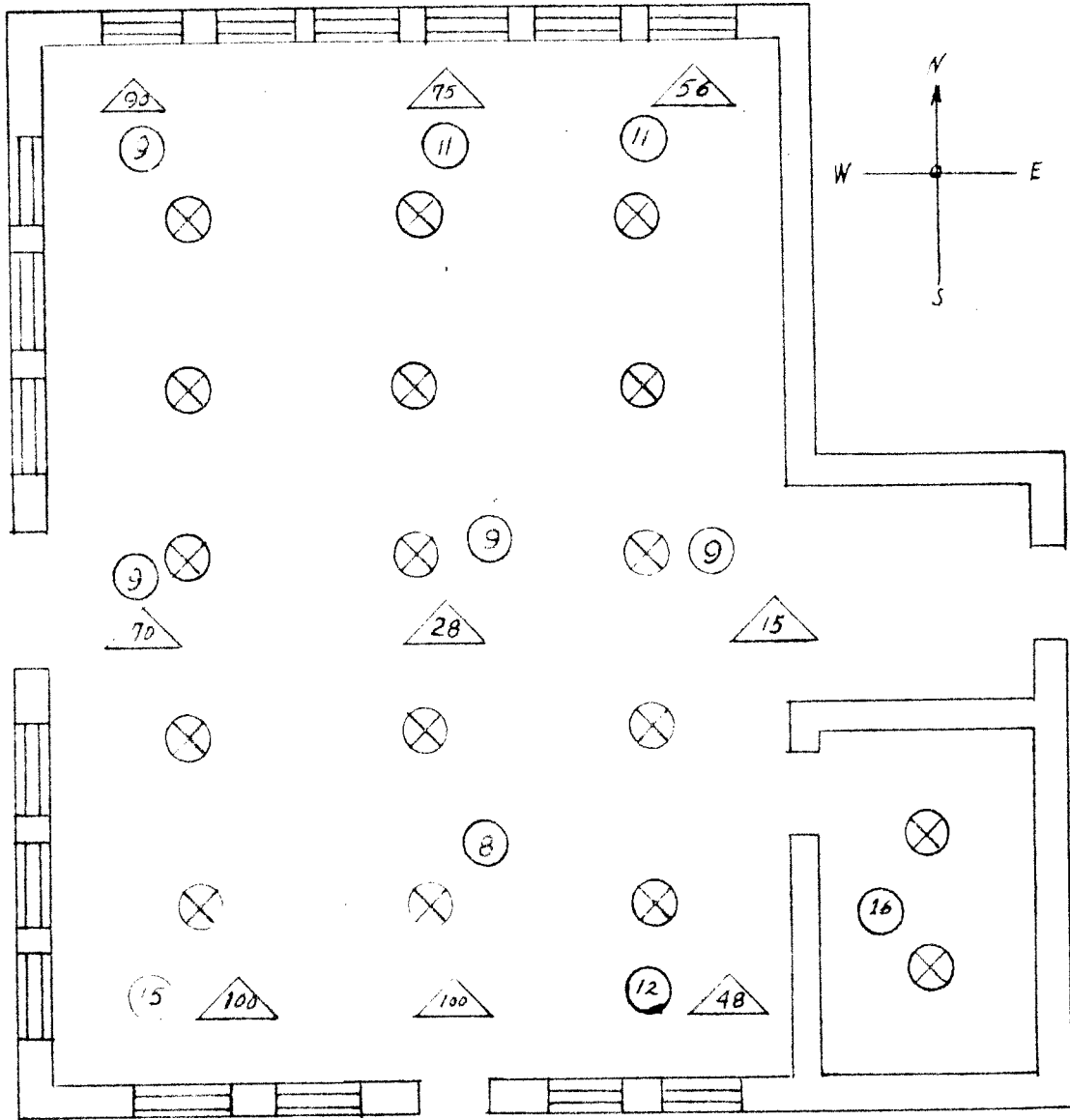


Time of Readings - 1:00 p.m.

Weather - Partly cloudy

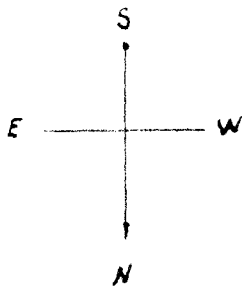
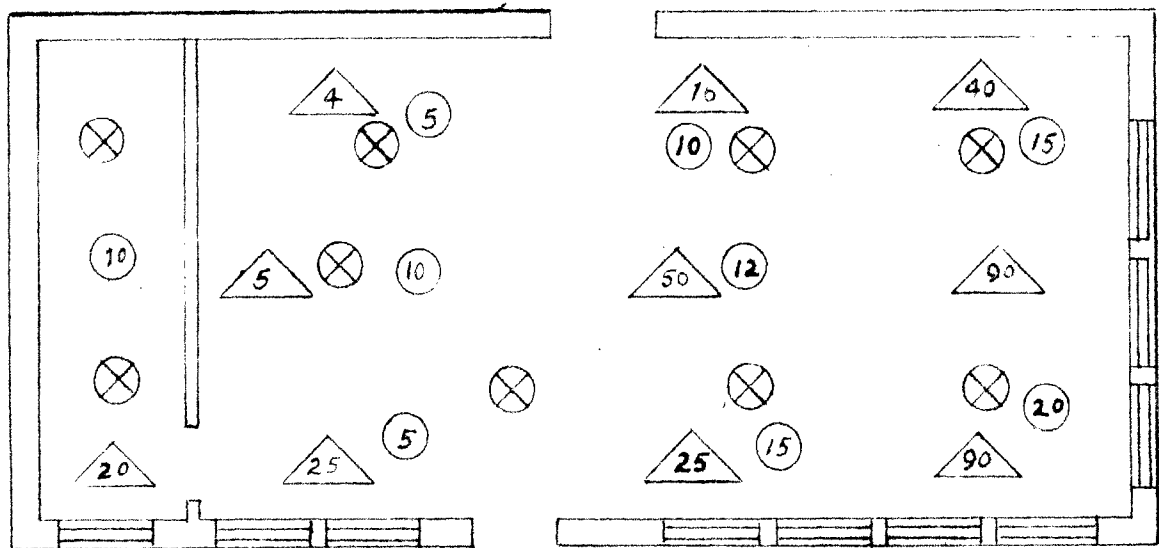
Ceiling Height - 12 Feet

Figure 2. W. P. McLean Junior High School General Shop



- △ Natural Light Readings
 - Artificial Light Readings
 - ⊗ Incandescent Lighting
- Weather - Clear
 Ceiling Height - 12 Feet
 Reading Time - 1:15 p.m.

Figure 3. Rosemont Junior High School General Shop



△ Natural Light Readings

○ Artificial Light Readings

⊗ Incandescent Lighting

Reading Time - 2:40 p.m.

Weather - Clear

Ceiling Height - 9 Feet, 4 inches

Figure 4. E. M. Daggett Junior High School General Shop

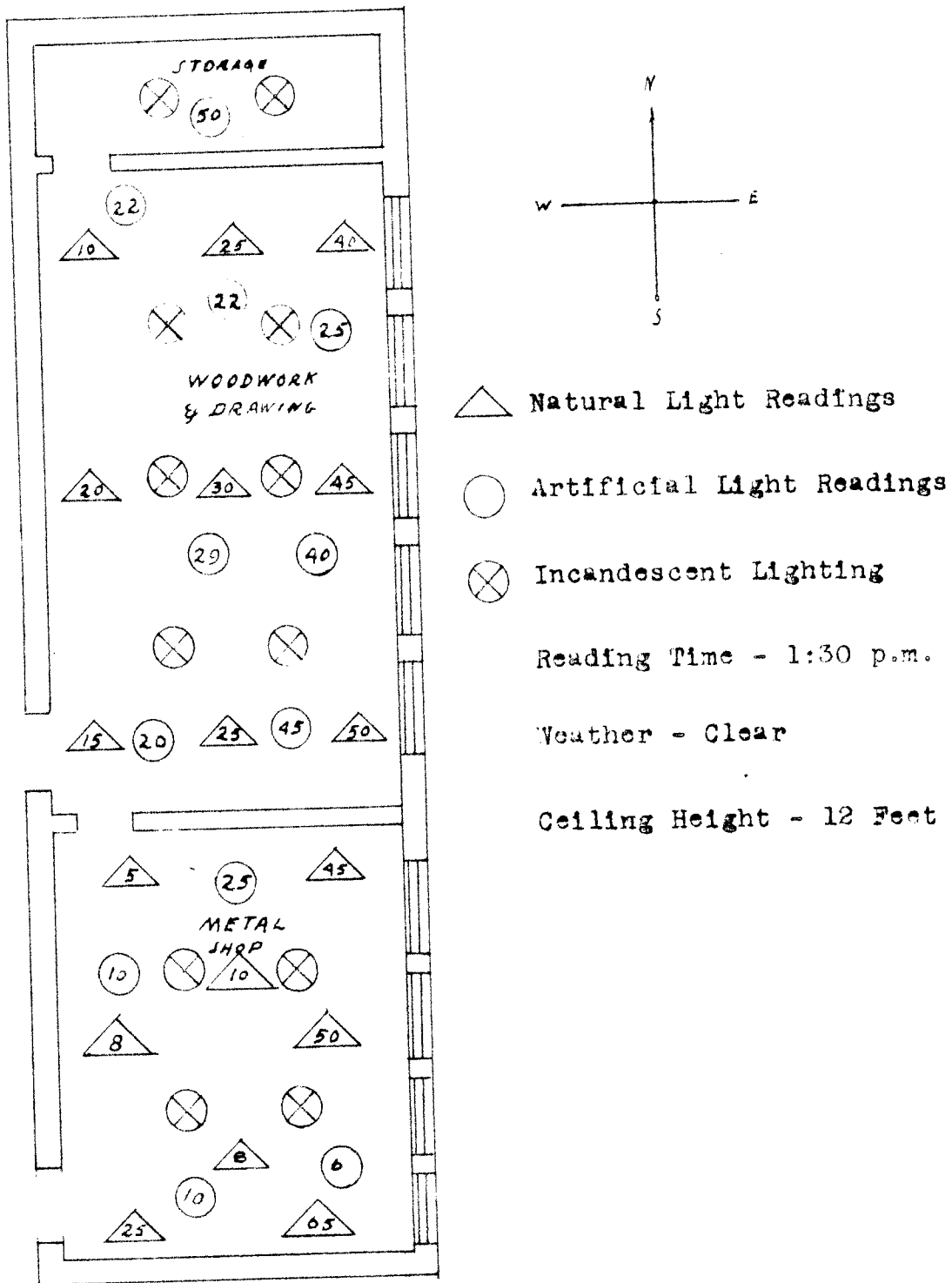
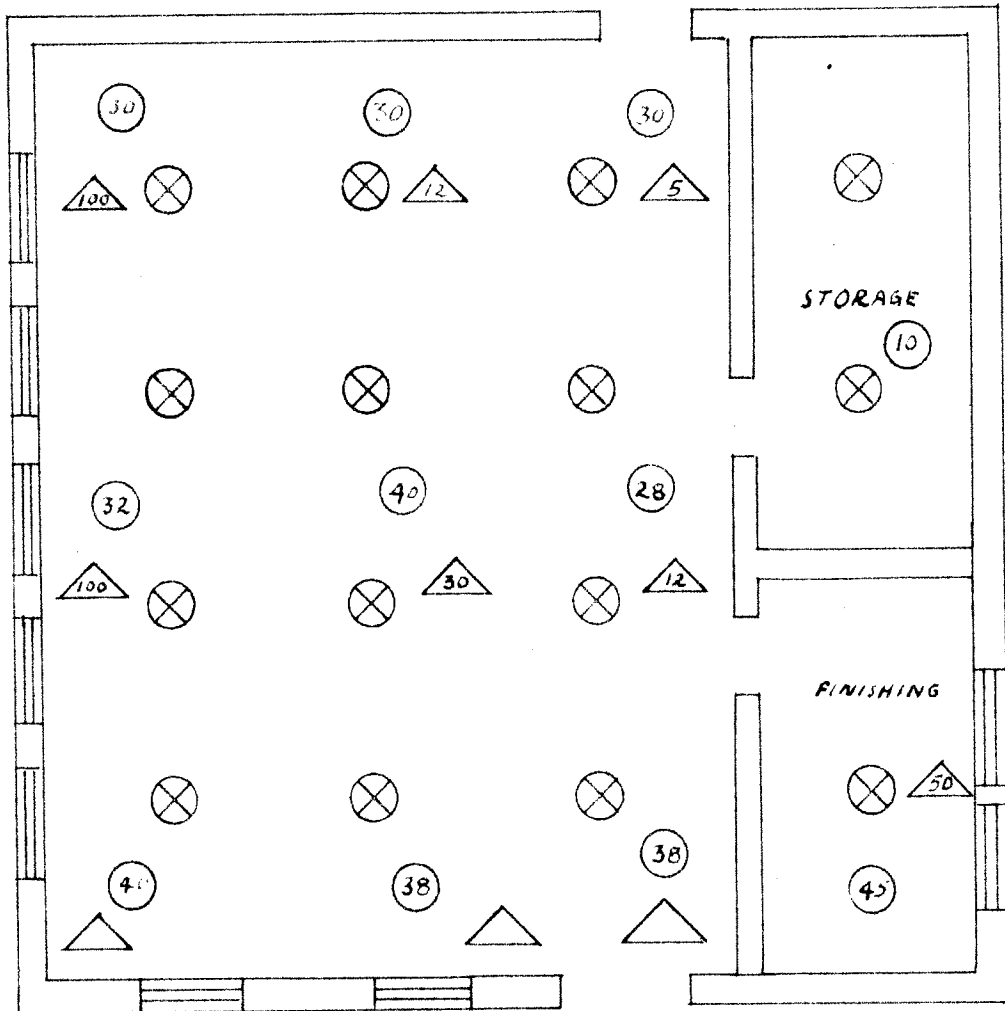
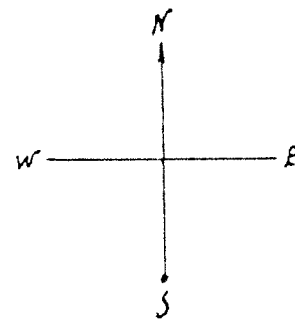


Figure 5. William James Junior High School Woodwork and Metal Shop



- △ Natural Light Readings
- Artificial Light Readings
- ⊗ Incandescent Lights

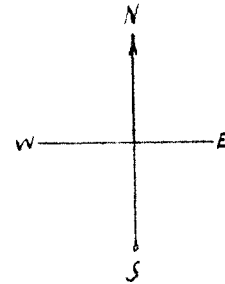
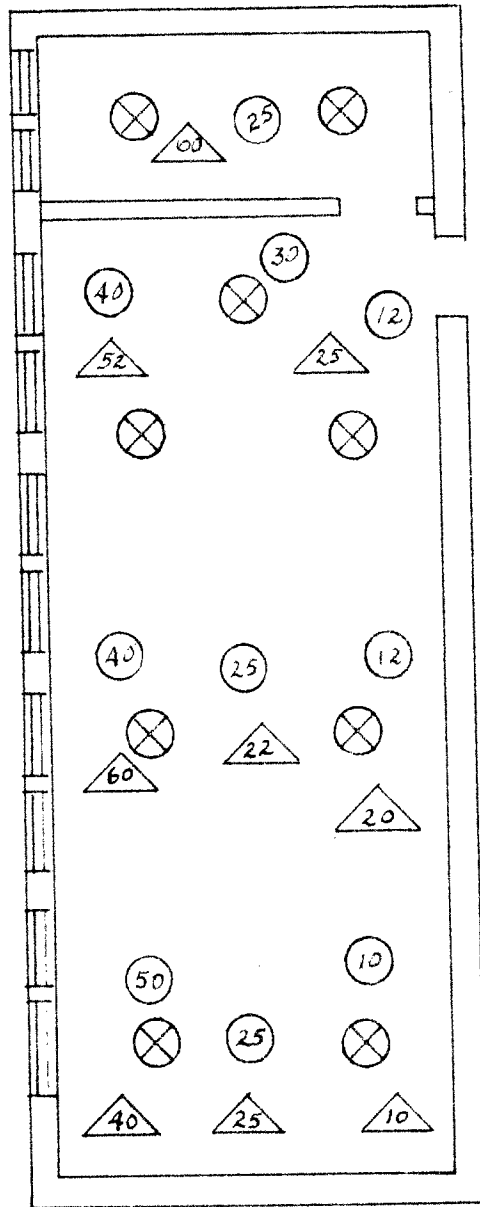


Reading Time - 1:40 p.m.

Weather - Partly Cloudy

Ceiling Height - 12 Feet

Figure 6. Meadowbrook Junior High School General Shop



Natural Light Readings



Artificial Light Readings



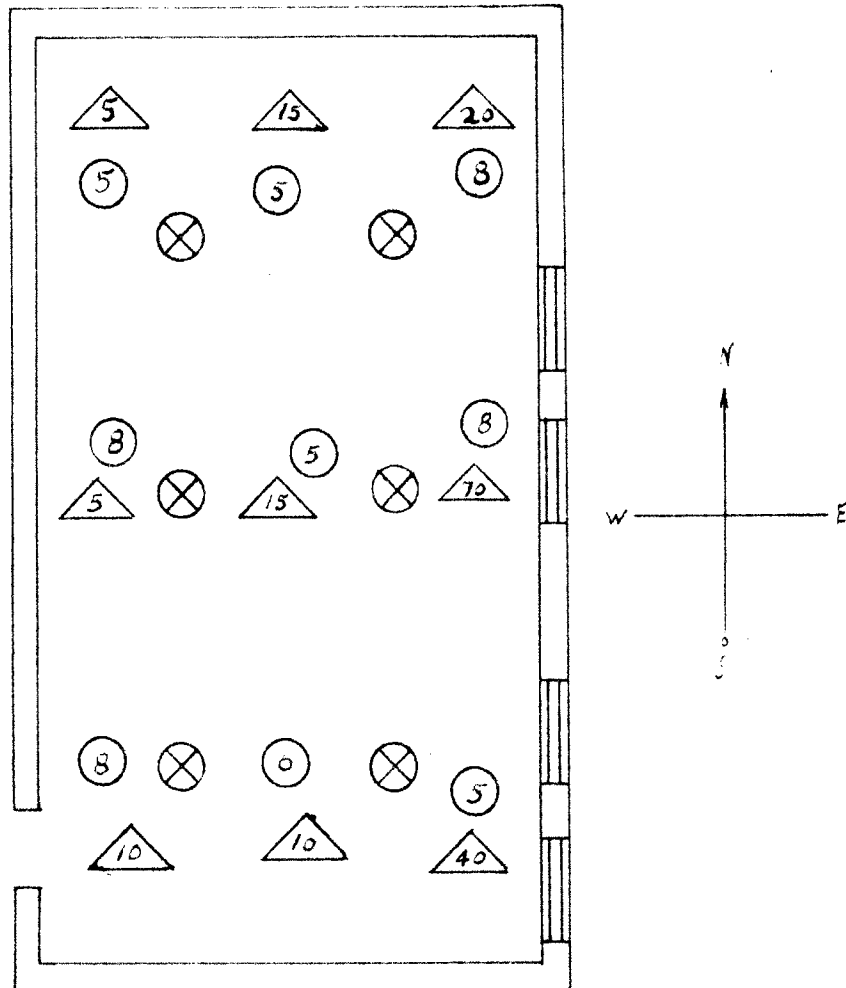
Incandescent Lights

Reading Time - 2:10 p.m.

Weather - Clear

Ceiling Height - 11 Feet

Figure 7. W. C. Stripling Junior High School Woodwork and Metal Shop



△ Natural Light Readings

○ Artificial Light Readings

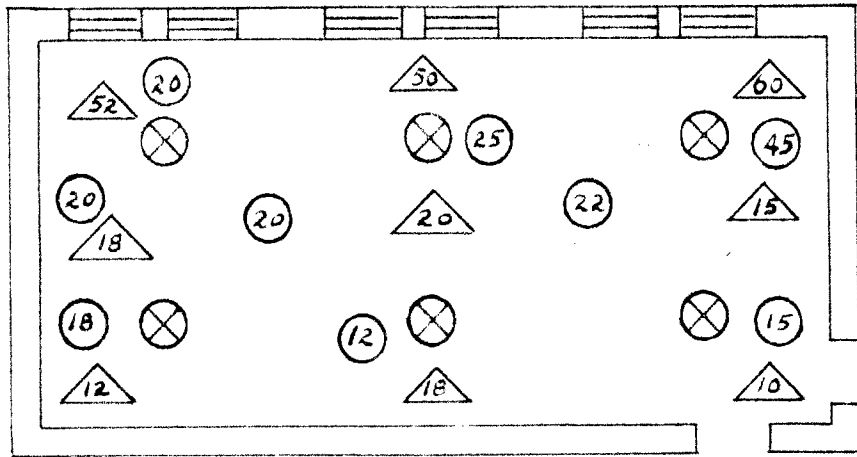
⊗ Incandescent Lighting

Reading Time - 1:30 p.m.

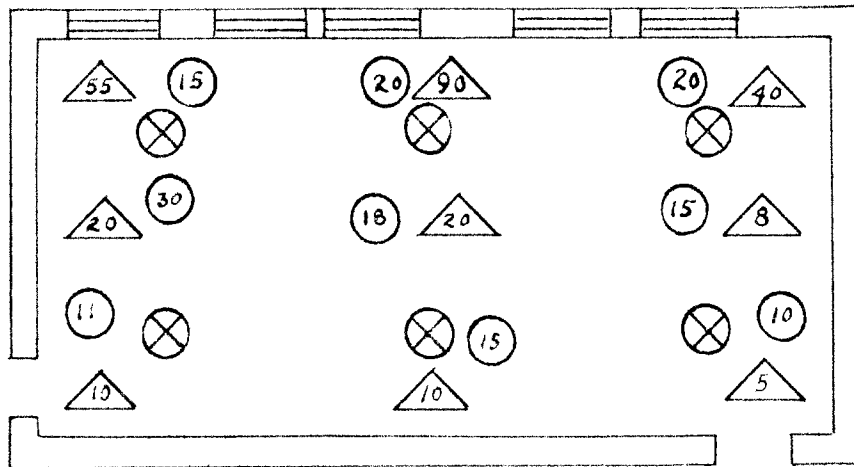
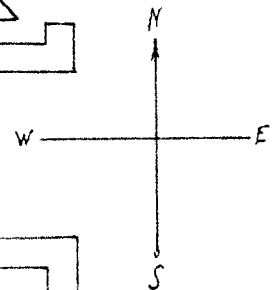
Weather - Clear

Ceiling Height - 11 Feet

Figure 8. W. C. Stripling Junior High School Electrical and Drafting Room



Woodwork Shop



Metal Shop

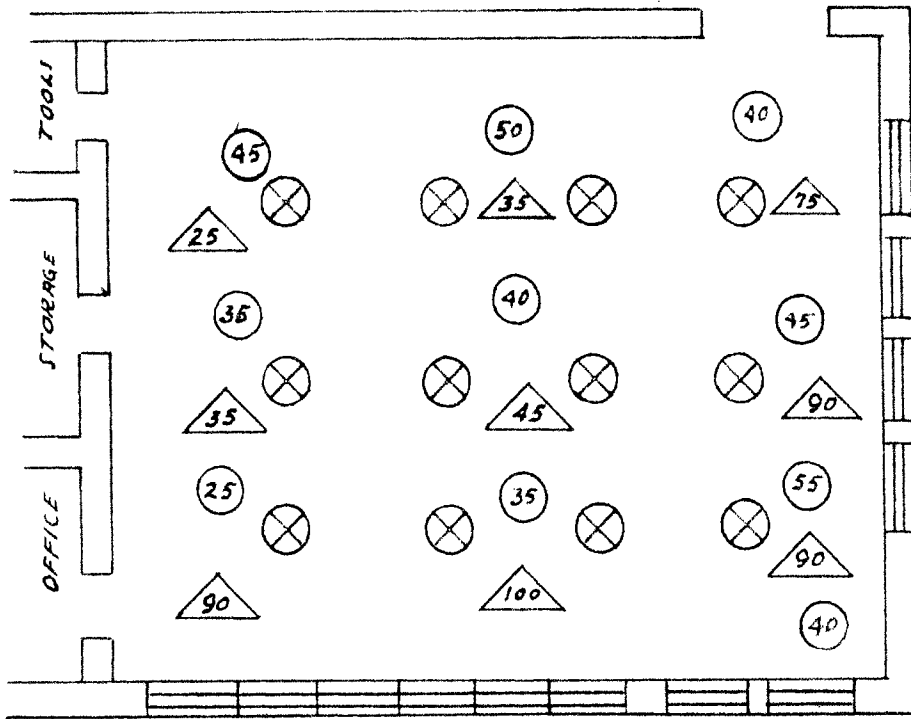
- △ Natural Light Readings
- Artificial Light Readings
- ⊗ Incandescent Lights

Reading Time - 1:30 p.m.

Weather - Clear

Ceiling Height - 12 Feet

Figure 9. J. P. Elder Junior High School Woodwork and Metal Shop



- △ natural Light Readings
 - Artificial Light Readings
 - ⊗ Incandescent Lights
- Reading Time - 11:15 a.m.
 Weather - Clear
 Ceiling Height - 14 Feet

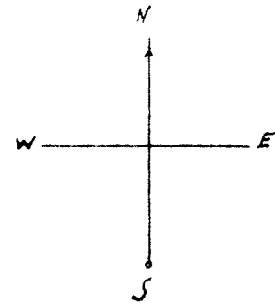
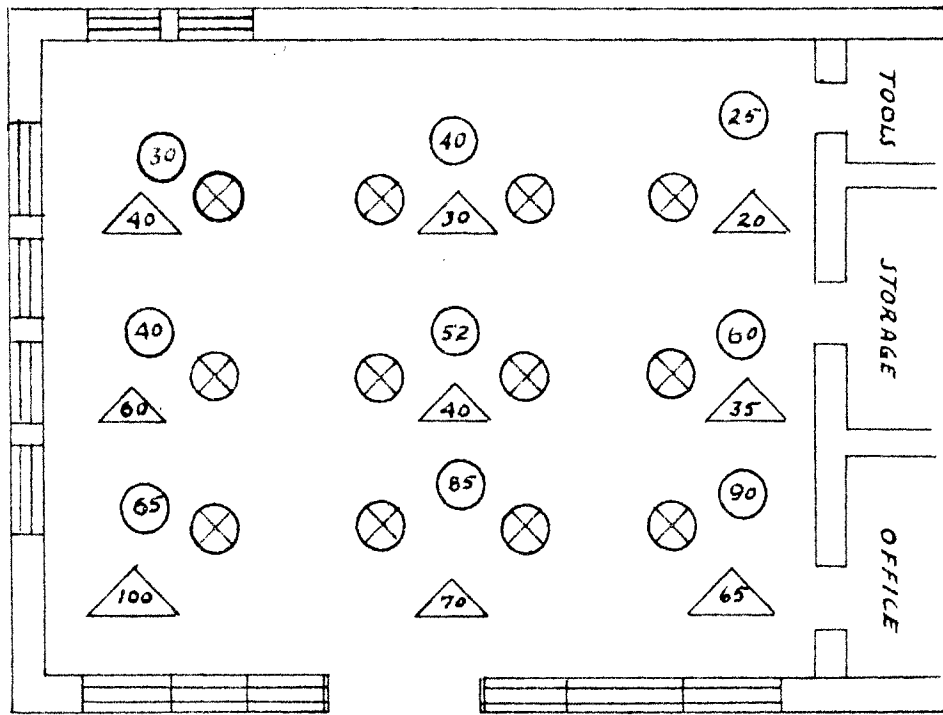


Figure 10. Riverside Junior High School
 Woodwork Shop



- △ Natural Light Readings
- Artificial Light Readings
- ⊗ Incandescent Lights

Reading Time - 12:15 p.m.

Weather - Clear

Ceiling Height - 14 Feet

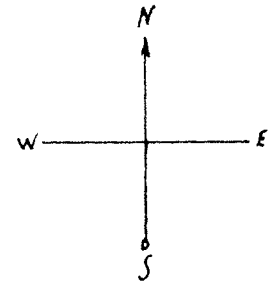


Figure 11. Riverside Junior High School Metal Shop

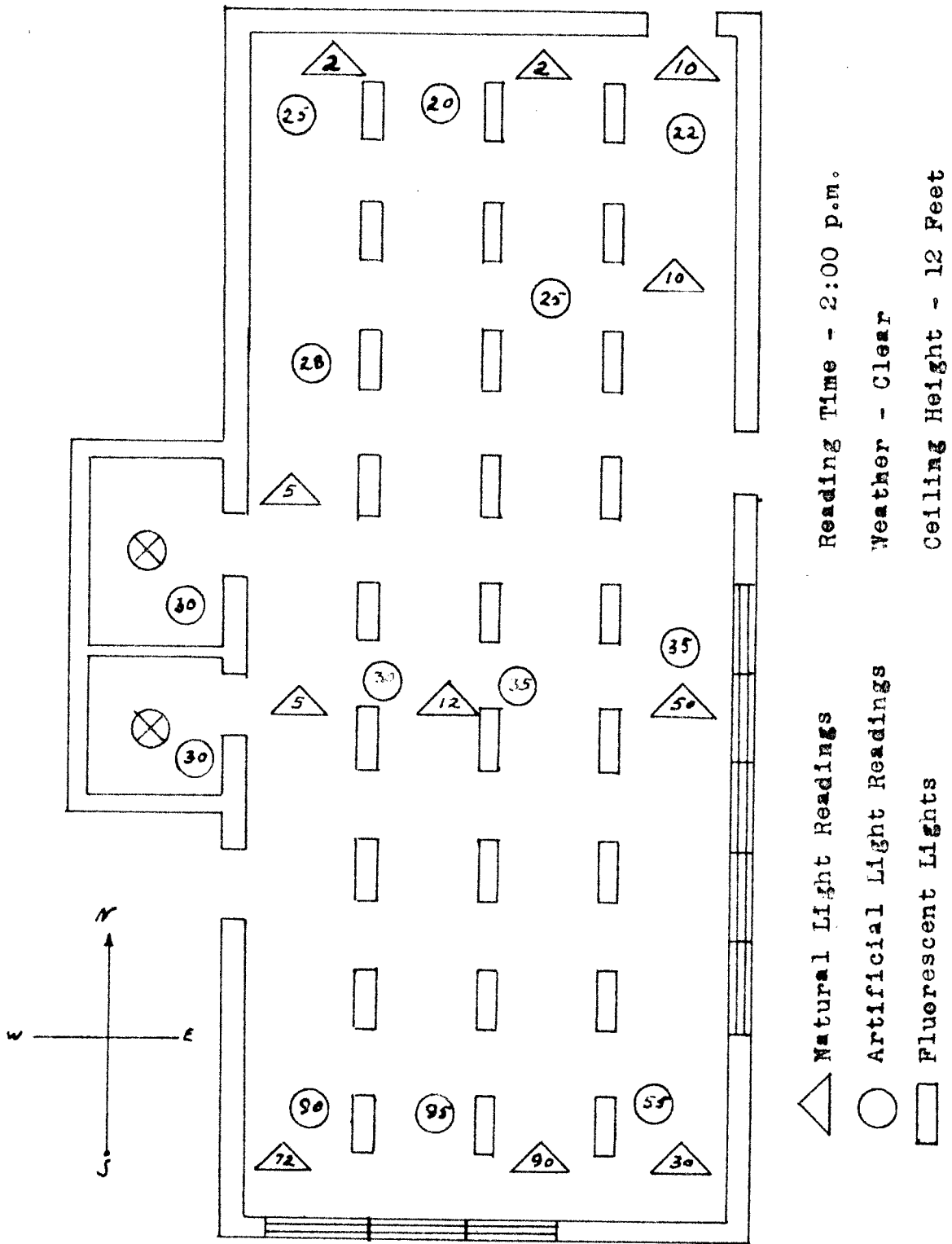


Figure 12. Paschal High School Woodwork Shop

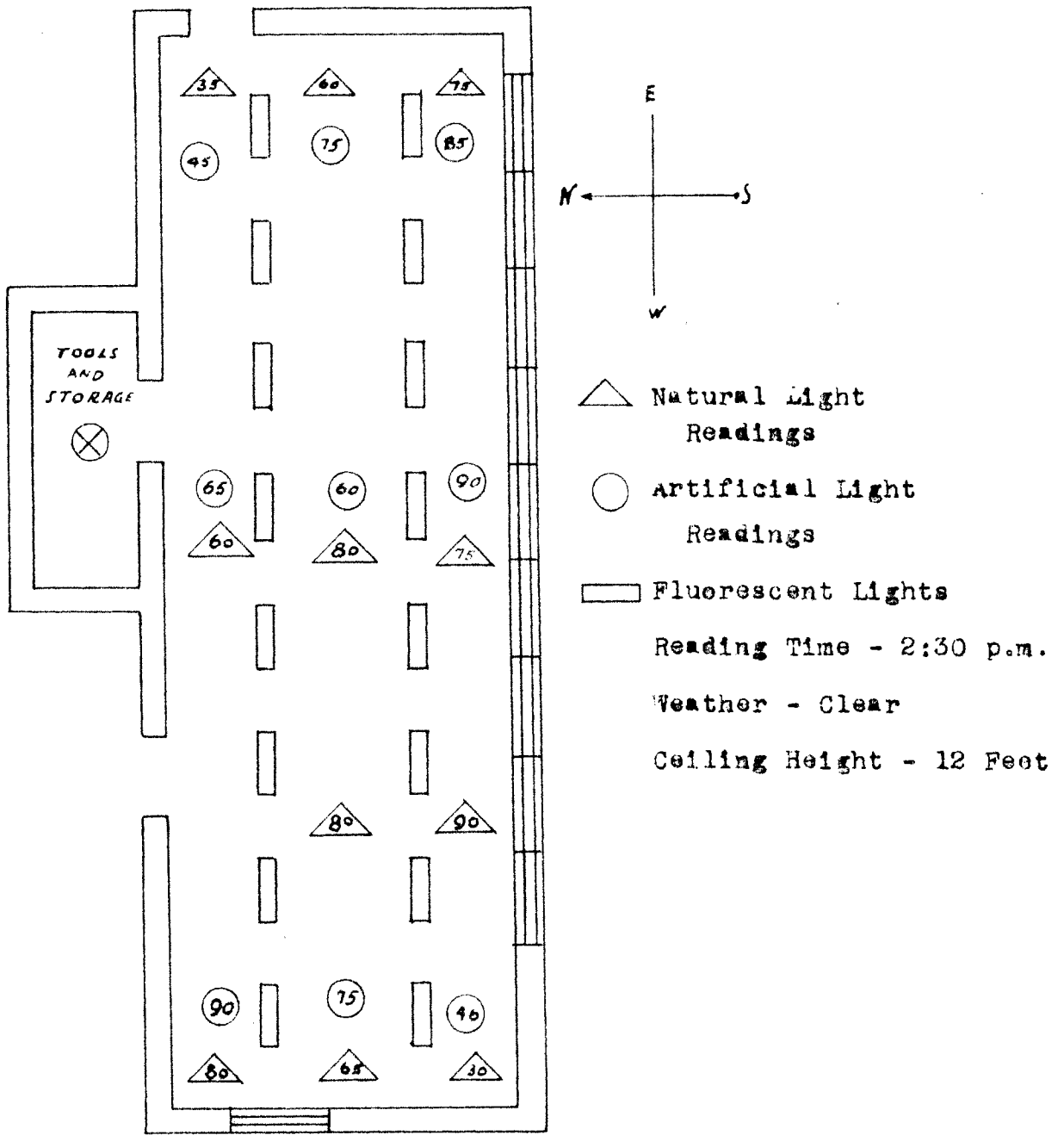
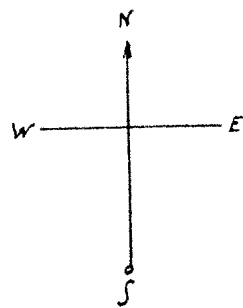
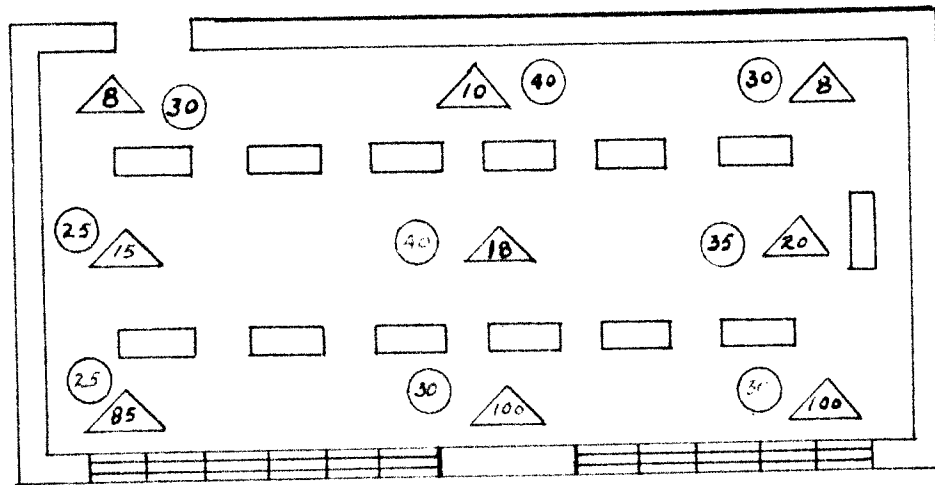


Figure 13. Paschal High School Metal Shop



- △ Natural Light Readings
- Artificial Light Readings
- ▭ Fluorescent Lighting

Reading Time 1:40 p.m.

Weather - Clear

Ceiling Height - 12 Feet

Figure 14. Paschal High School Drafting Room

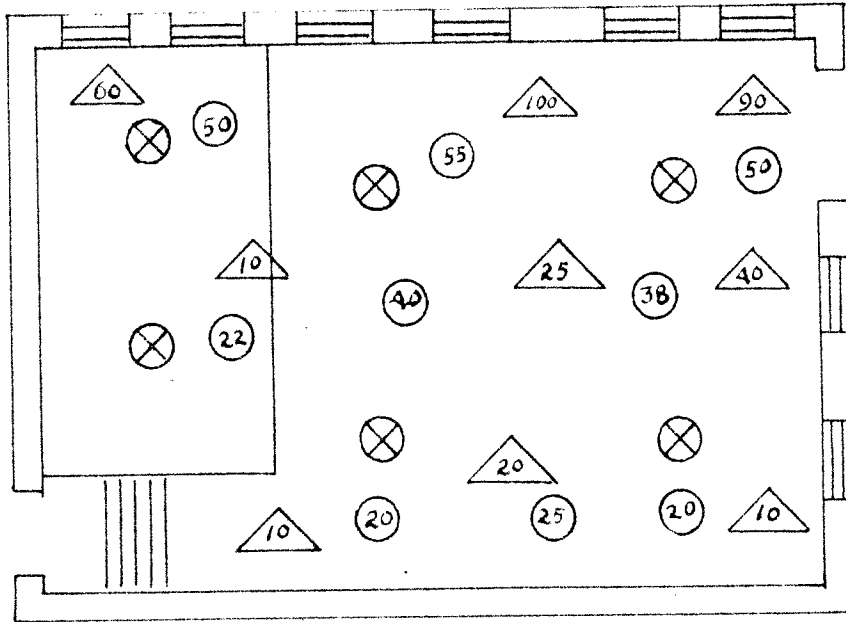
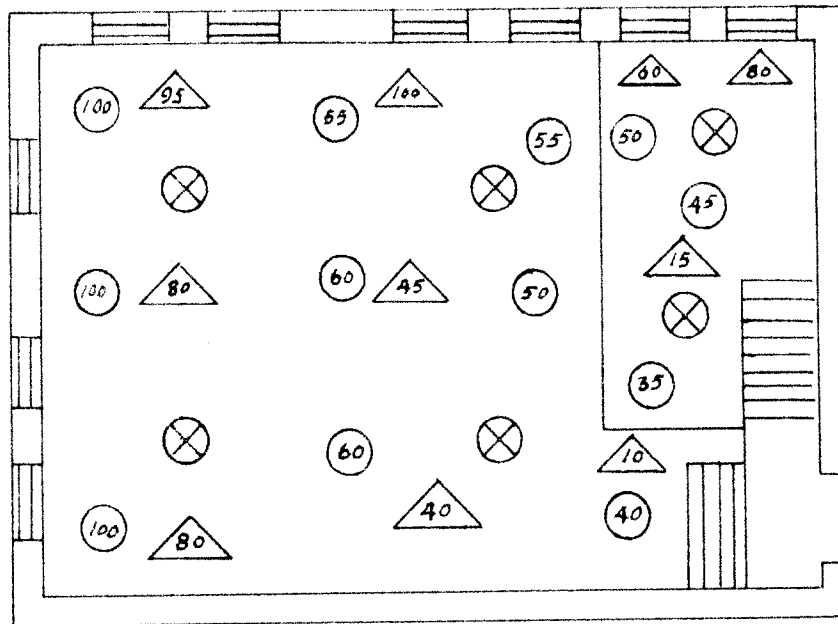
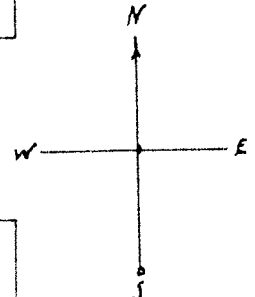
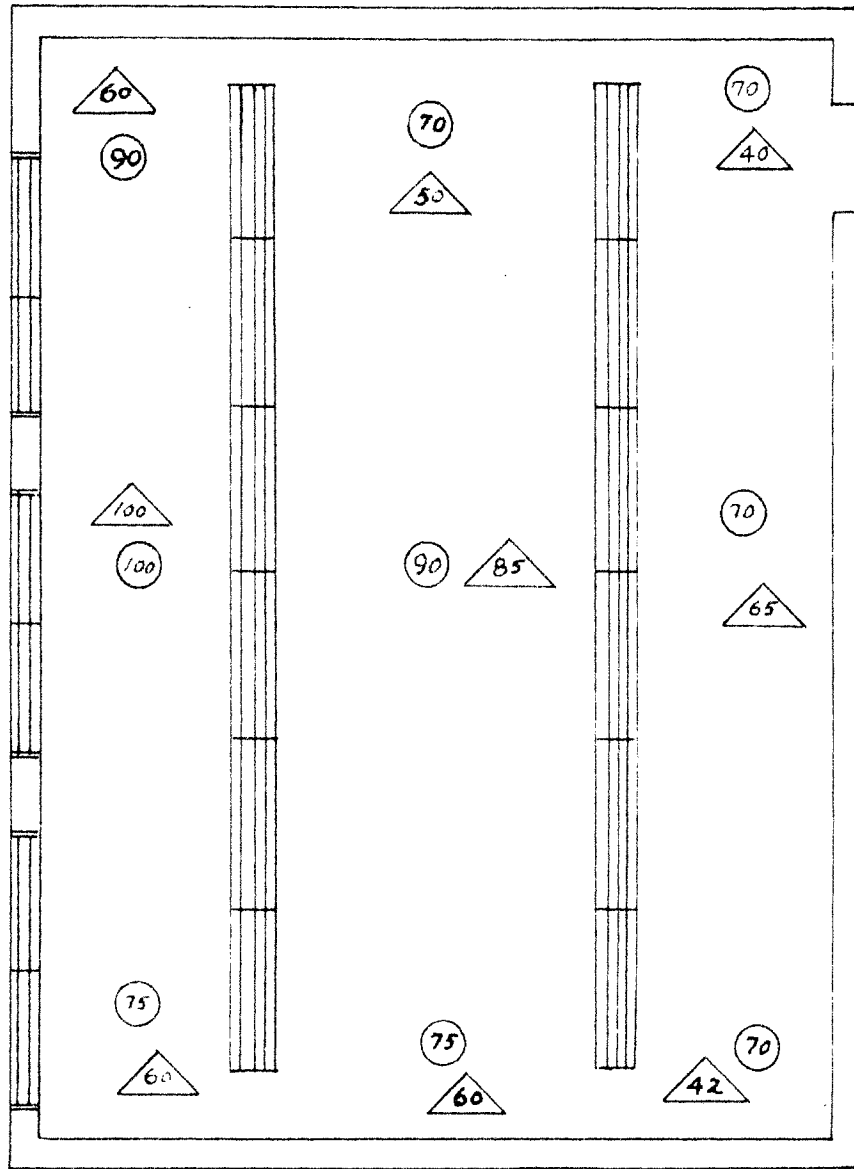


Figure 15. Northside High School Metal Shop



- △ Natural Light Readings
 - Artificial Light Readings
 - ⊗ Incandescent Lighting
 - Ceiling Height - 14 Feet
- Figure 16. Northside High School Woodwork Shop



- △ Natural Light Readings
- Artificial Light Readings
- ▨ Fluorescent Lighting

Reading Time - 1:00 p.m.

Weather - Clear

Ceiling Height -

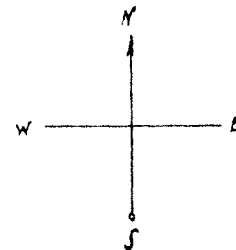


Figure 17. Northside High School Drafting Room

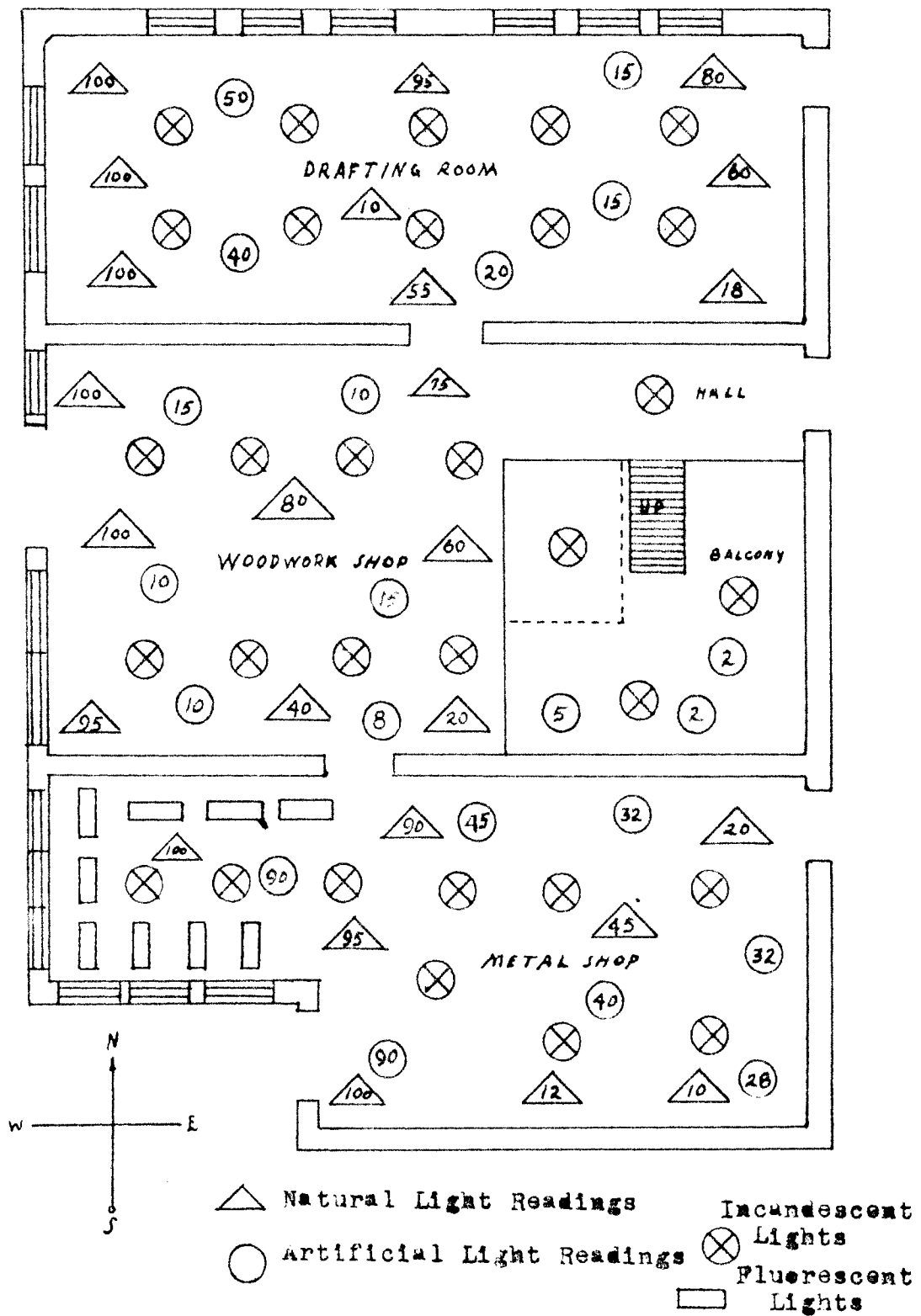
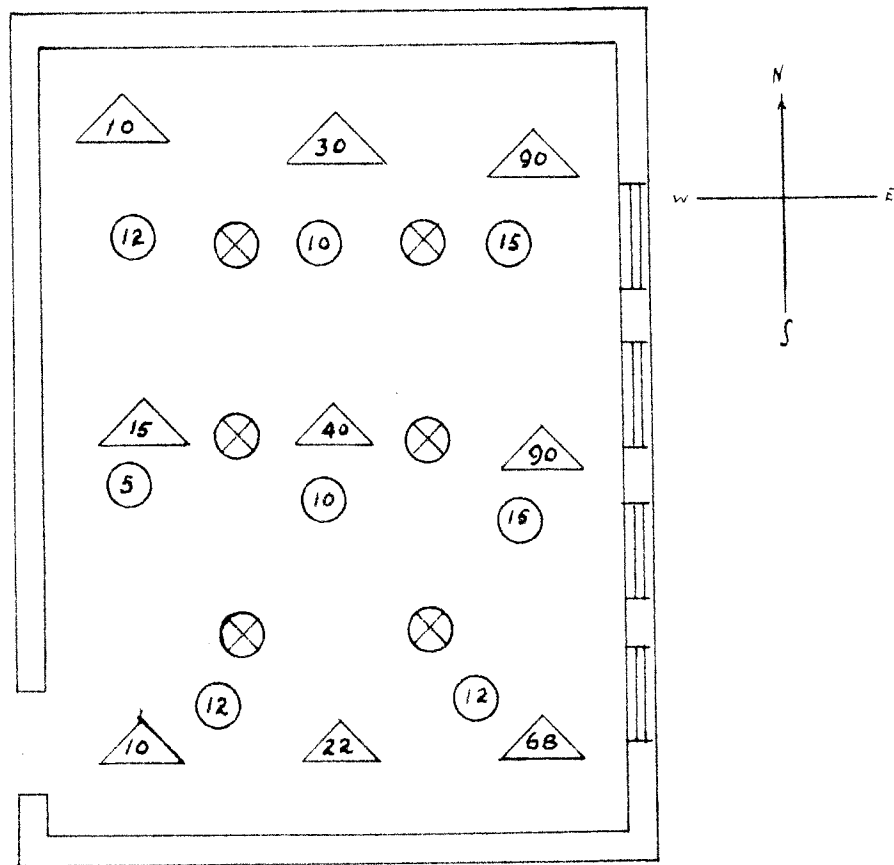


Figure 18. Polytechnic High School Drafting, Woodwork, and Metal Shop Rooms



- △ Natural Light Readings
 - Artificial Light Readings
 - ⊗ Incandescent Lights
- Reading Time - 11:30 a.m.
 Weather - Partly cloudy
 Ceiling Height - 11 Feet

Figure 20. Riverside High School Drafting Room

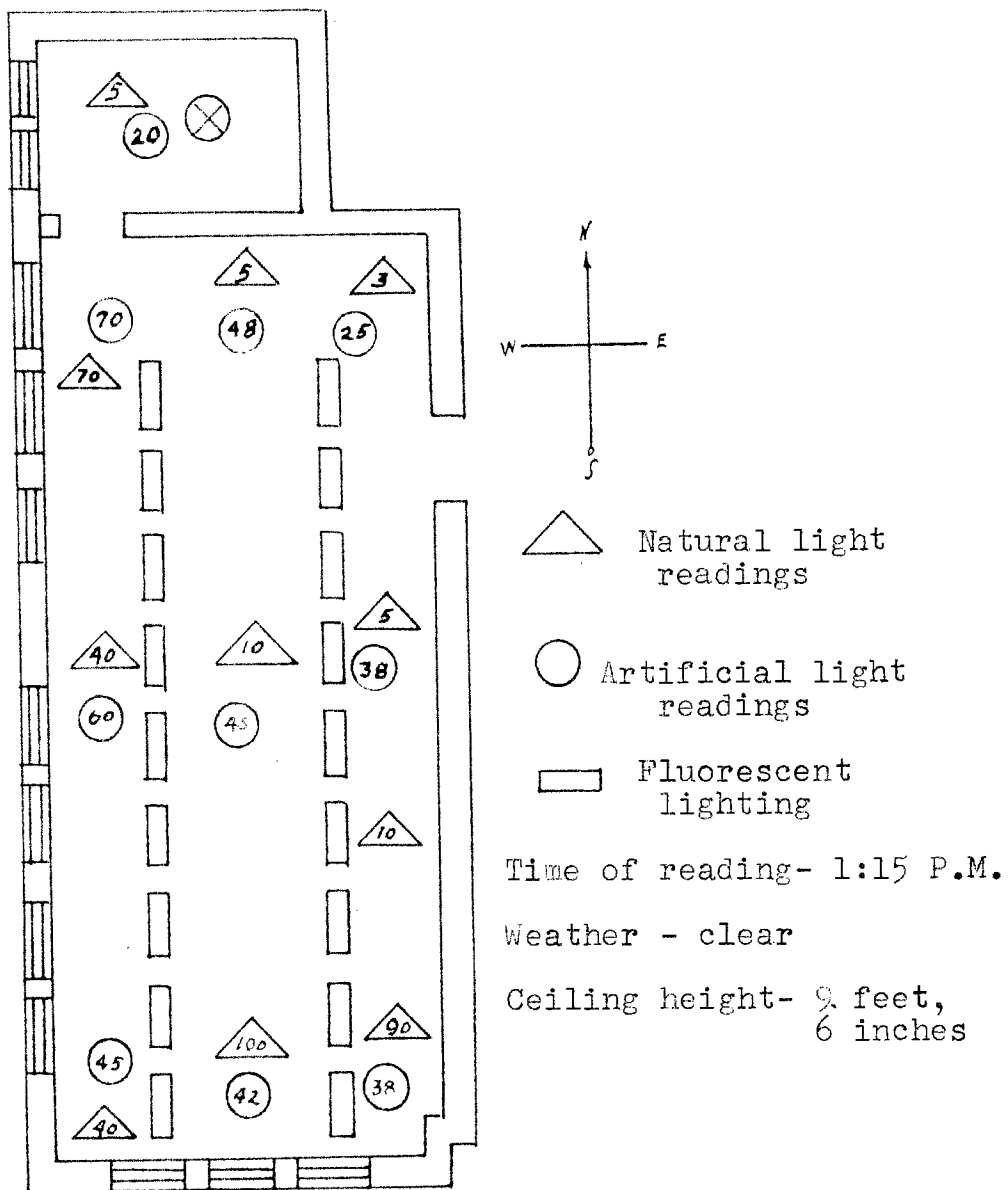
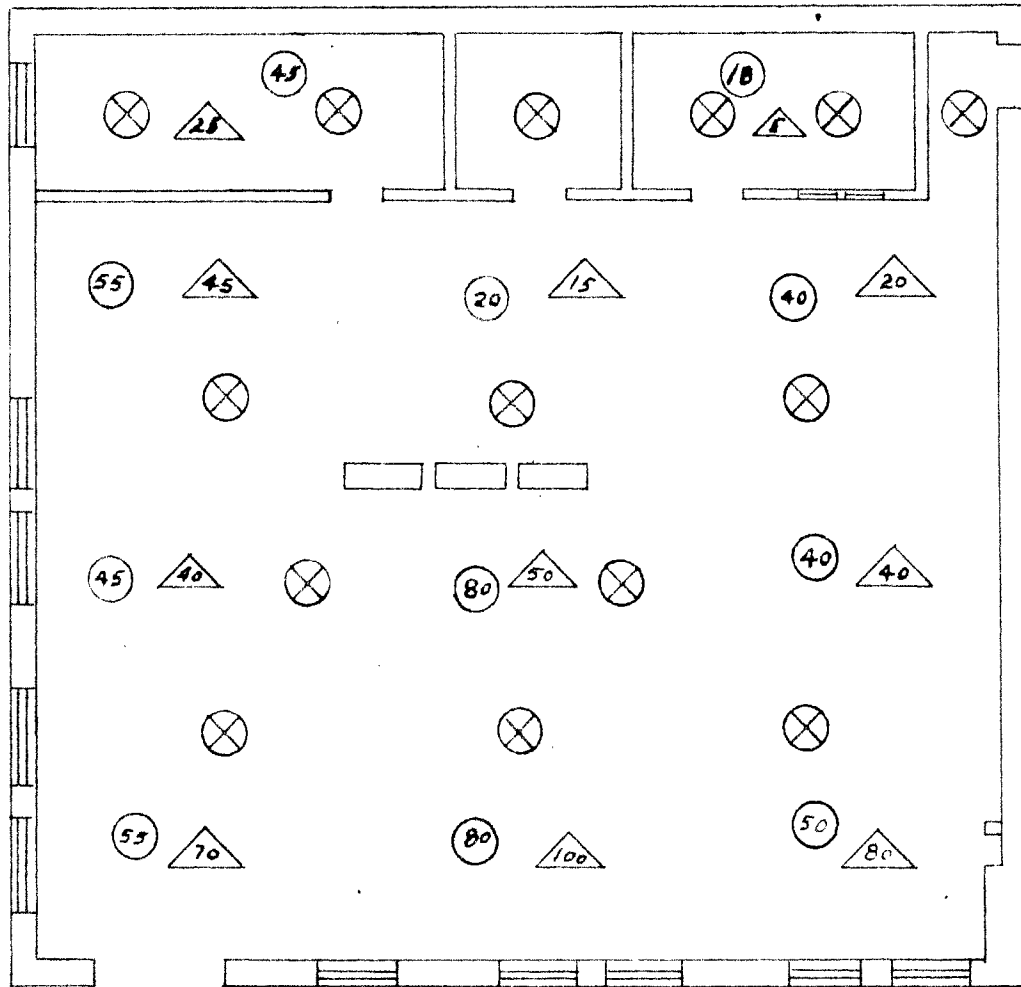


Fig. 21.--Diamond Hill General Shop

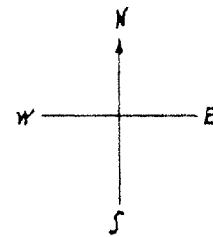


△ Natural light readings

○ Artificial light readings

▭ Fluorescent lighting

⊗ Incandescent lighting

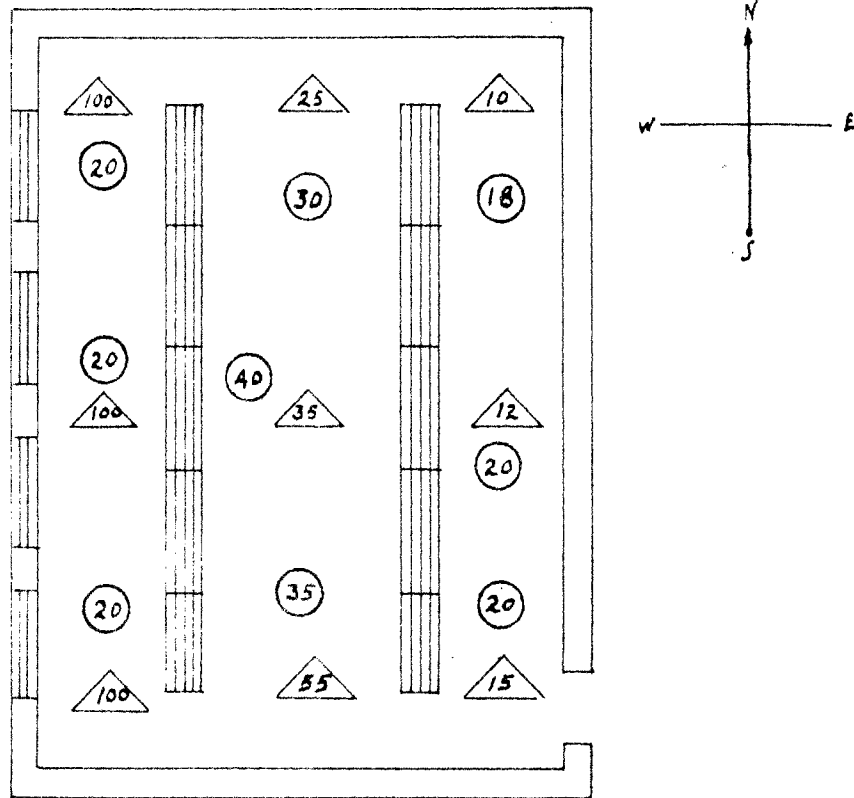


Time read: 1:30 P.M.

Weather - clear

Ceiling height 12 feet

Fig. 22.--Arlington Heights High School Wood and Metal Shop.



△ Natural light readings

○ Artificial light readings

▨ Continuous fluorescent lights

Time read - 1:00 p.m.

Weather - clear

Ceiling height - 10 feet, 6 inches

Fig. 23.--Arlington Heights High School Drafting Room

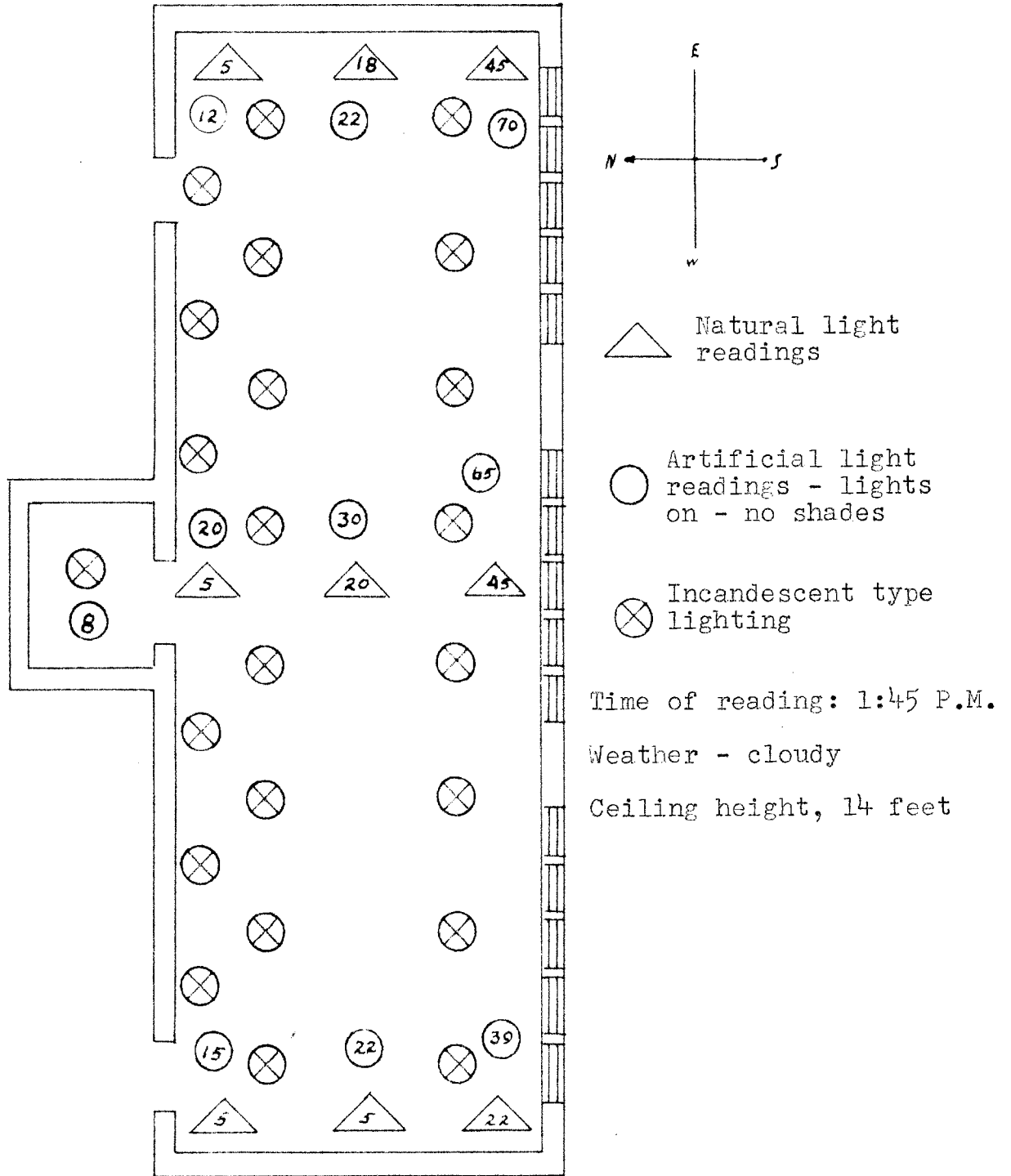


Fig. 24.--Handley High School General Shop

BIBLIOGRAPHY

Books

- ✓ Dunham, Clarence W., Planning Industrial Structures, New York, McGraw-Hill Publishing Company, 1948.
- Mays and Casberg, School Shop Administration, Milwaukee, Wisconsin, Bruce Publishing Company, 1949.
- ✓ Sexton, R. W., Schools, New York, Architectural Book Publishing Company, Inc., 1939.
- Wilber, Gordon O., Industrial Arts in General Education, Scranton, Pennsylvania, International Text Book Company, 1949.

Public Documents

- Illuminating Engineering Society, American Recommended Practices of School Lighting, New York, Revised Edition, February, 1947.

Articles

- ✓ Bursch, Charles, and Gibson, Charles, "Daylighting the School Plant," American Schools and Universities, XVIII (1944-1945), 77.
- Essex, Don L., "Lighting for School Buildings," American Schools and Universities, XX (1948-1949), 127.
- ✓ Putman, Russel C., "The American Standard Practices of School Lighting," The American Schools and Universities, XXI (1949-1950), 301.

Magazines

- ✓ Bollinger, Elroy W., "Securing the Right Kind of Light," Industrial Arts and Vocational Education, XXII (February, 1933), 132-138.
- ✓ Warner, William E., "Studies in School Shop Planning," Industrial Arts and Vocational Education, XXII (February, 1934), 31-38.