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ABSTRACT

Factors for consideration by an industrial education planning committee are discussed. Selection, purchasing, and storage of new types of equipment and supplies, in addition to students' project storage, are noted as worthy of consideration in planning the shop facility. Planning factors for the various types of industrial arts laboratories are discussed with reference to suggestions relating to room sizes and relationships to other programs. Shop architecture specifications are presented for auxiliary rooms and facilities, heating and ventilation, plumbing, and lighting. A bibliography is included. (FS)

INDUSTRIAL EDUCATION FACILITIES

Bulletin No. 2135
Revised 1964

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Lynn M. Bartlett, State Superintendent
Division of Vocational Education
Lansing, Michigan

CONTENT

FOREWORD

In the planning of new facilities or in the alteration of existing structures, school administrators are called upon to supply consultant services to architects so that the facilities will be adaptable to the unique needs of the various educational purposes for which the building is planned.

Understanding the needs of all phases of the educational program has been difficult for administrators because of the specialized knowledge which is required. Traditional industrial arts and industrial education programs have been expanded to include units on plastics, hydraulics, foundry, power mechanics, electricity, graphic arts, and others in addition to woodworking and metal working. Selection, purchasing, and storage of new types of equipment and supplies in addition to students' project storage are areas worthy of consideration in planning the shop facility.

In order to provide some assistance to school administrators, teachers, and architects, the State Curriculum Committee for Industrial Arts Education has prepared this bulletin on school shop planning. Included are suggestions relating to room sizes, relationships to other programs, and a host of other points considered essential to good school shop planning.

This bulletin should prove useful in the solution of many of the problems involved in developing industrial arts facilities. It encompasses the ideas of leaders and teachers in the architectural and teaching area concerned. Revision has, therefore, resulted from the usage of the previous bulletin and application of ideas secured through workshop techniques.

May I take this opportunity to thank all members of the committee and other persons who participated in this worthwhile venture, with special recognition to the members of the subcommittee.

Lynn M. Bartlett

Lynn M. Bartlett
Superintendent of Public Instruction

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The committee wishes to acknowledge the advice offered by several school administrators who generously gave of their time to make a critical analysis of this bulletin.

TERMINOLOGY

Industrial Education is a generic term encompassing industrial arts and industrial vocational education.

Industrial Arts involves preparation, growth, and guidance for modern living through experiences with materials, tools, and industrial processes, and of the related social and economic significances to the student, the home, the community and the nation.

Industrial Vocational Education is that phase of vocational education which is planned to assist an individual in developing manipulative skills, safety practices, trade morale, and related industrial information essential to employment in the occupation for which training is given.

General Shop is a laboratory in which more than one area of work is taught usually simultaneously with breadth of experience offered rather than depth. General shops are usually classified as limited or comprehensive.

a. Limited General Shop is one in which more than one related area of work is taught such as general woodworking which may include areas of cabinet work, patternwork, wood carving, wood turning, and others; or general graphic arts which might include areas of letter press, paper making, intaglio, planography, stenciling, and others.

b. Comprehensive General Shop is one in which several unrelated areas of work are taught such as crafts, metal work, woodwork, graphic arts, and electricity.

Unit Shop is a laboratory in which some single occupational area of work, such as automechanics, printing, welding, carpentry, or metal machining is taught and is generally vocational in nature.

Work Station is a location at which a pupil may be engaged in a learning activity.

Planning Area is a location that houses resource materials, visual aids, technical references, and appropriate equipment for pupil use.

Storage Centers are areas where tools, supplies, materials, and projects may be stored.

SECTION I
PREPLANNING FOR SCHOOL SHOP AND FACILITIES

INDUSTRIAL EDUCATION PROGRAMS IN MICHIGAN SCHOOLS

School administrators are confronted with the ever increasing necessity of developing educational programs to meet the needs of youth and adults. Industrial education is that facet of the educational spectrum which is concerned with life in an industrial society. As a result of rapid growth in scientific and technological developments, industry has become more complex, diversified, and automated. These are factors to which planners of industrial education programs must be sensitive.

Schools are coming more and more to be recognized as service agencies for an entire community. This attitude presents some rather interesting implications for the industrial education program if it is to be consistent with educational and community goals. It would seem to mean that school shops should be planned in a manner which provides flexibility and adaptability of space and equipment so that it will be versatile over a wide range of instructional activities. It may well be that the shop will provide for adult activities of both a technical nature and for avocational pursuits.

The key to planning good facilities would appear to be flexibility, for although the school plant is designed for present known needs, a farsighted approach which provides flexibility of space, equipment, and utilities (gas, electricity, water, compressed air) will be less apt to restrict change in the future.

Today we are living in an industrial-technological-scientific culture characterized by rapid change. Planning a facility or facilities which will permit a curriculum needed by youth and adults living in this complex society is a task deserving of the assistance of an advisory committee. The membership for this committee should be chosen from knowledgeable people representing education, labor and management.

SUGGESTIONS FOR THE ADVISORY COMMITTEE

A. Planning Committee Representation

Determining the nature and extent of industrial education facilities is essentially a local concern. The community being aware of its problems and needs may begin planning the industrial education facilities with the selection of a representative committee of qualified local citizens. A community planning committee should include representation from faculty, architect, parents of school children, industry, and other interested lay groups.

The committee:

1. Must adopt or formulate a basic philosophy of education.
2. Must know its responsibilities.
3. Must be flexible.

4. Must be allowed to work at its own speed.

5. Must be so structured that it can profit and grow from its own failures and disagreements.

6. Must have financial means to obtain expert assistance.

7. Must analyze society as it exists and its trends (assistance of experts required).

8. Must understand the nature of the learner and how he learns. Professional assistance is available and may be needed.

9. Must examine the curriculum as it exists in their present school and revise as necessary.

B. Factors for Consideration by a Planning Committee

In the planning of any public building, or in the making of alterations and modernizations, certain questions will arise and demand answers. Some questions which are frequently asked by a group making plans for the building of a shop are:

1. What are the present and future needs of the community?

2. To what extent will the school shops be used by the entire community?

3. What are the avocational interests of the community?

4. Will the shop be needed for a dual function?

5. Where can information and assistance in planning be secured?

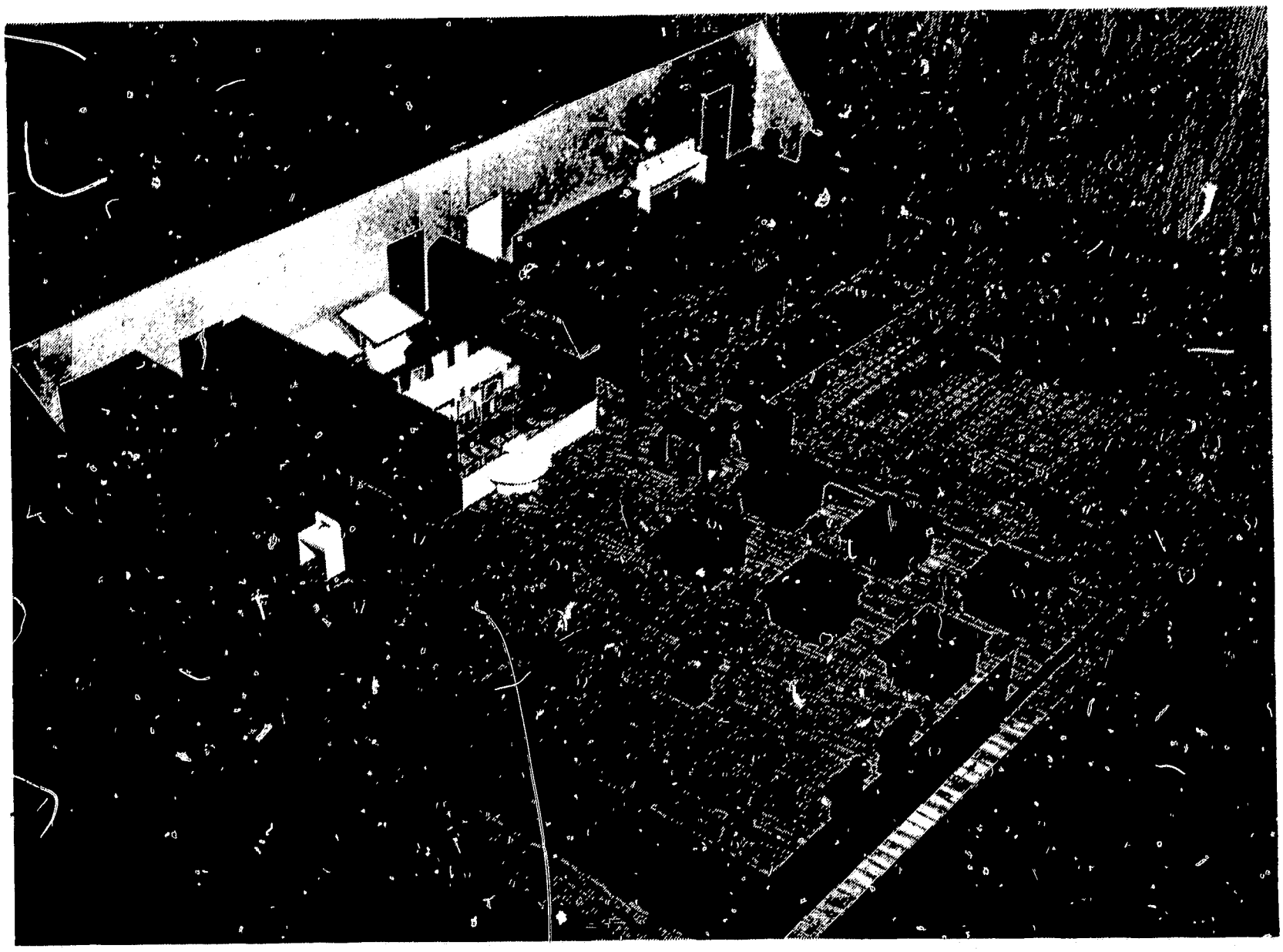
6. What length of time will be needed to complete the building?

7. What information should be given out during the period of building?

8. How will the construction be financed?

9. To what extent will the school shops be used as resource areas for other school subjects concerned with man's needs; food, shelter, clothing, transportation, and communication?

10. To what degree can flexibility in the physical plant be incorporated to provide for future curriculum changes?



An example of three dimensional planning

C. Shop Selection

One of the first problems to solve is the extent of the shop course content. Needless to say, the subjects offered should be such that the objectives may be realized. In general, subject or course offerings may be considered in one of three broad situations of school enrollment, namely: (1) the one teacher general shop, (2) the two teacher department, or (3) the large department.

Total school enrollment to a large degree influences the type of shop and in turn the number of shops. In all cases the type of shop should be determined by the needs of the students, its value to the school, the use of space and equipment, and efficiency of teaching. A comprehensive general shop is well suited to a school in which the enrollment indicates a need for one shop.

In communities needing two or more shops many factors control their choice. If the emphasis is to be on industrial arts, then the comprehensive and/or limited general shop is recommended rather than the unit shop. Unit shops are recommended for programs in which depth of subject matter is desired.

A practical mathematical formula often used to approximate the number of shops to be included in the plans is as follows:

$$\frac{\text{Total number of pupils to be involved in the industrial arts program}}{\text{Number of classes per day} \times 24 \text{ (24 recommended maximum load per class)}}$$

DETERMINING PHYSICAL FACILITIES

A. General Principles

1. The physical facilities for industrial arts are determined by the kind of program desired.

2. Each situation will be affected by the conditions in the community, facilities presently available, and the size of the buildings. Instructional facilities should be provided so that an optimum industrial arts program may be offered to all students.

3. The interests of youth are as varied as those of adults. Model planes, radio, wood carving, jewelry making, plastics, archery, electrical, graphic arts, and mechanics are only some of the activity interests.

4. Although most students have needs and interests which are common regardless of the community in which they live, the industrial arts program should be able to accommodate the needs and interests peculiar to each community.

5. Industrial vocational education needs are very often included in the total shop programming of a school and should be recognized when planning an industrial arts program.

6. While compromises may be necessary between shop layout and the architect's plans, the final analysis demands that the shop be functional and of adequate size to fulfill the objectives of the curriculum.

7. The actual planning and layout of equipment should be done by experienced shop teachers in cooperation with administrators and architects.

8. The quantity, size, and kind of equipment is of necessity determined by the proposed instructional program.

9. The cost of building can be stabilized by the standardization of items such as finish and materials, walls and ceilings, wiring, floors, and lighting utilizing the latest advances in construction and materials.

10. Utilize as many sources as possible for information on shop planning. (Page 2, Item B, 9-10; Page 3, Item C.)

B. Sources of Information on Planning

1. Visit well-planned shops which have recently been constructed, but do not duplicate without further study.

2. Consult with representatives of teacher education institutions which have planning services available.

3. Obtain suggestions from experienced industrial arts directors and teachers.

4. Consult the State Department of Public Instruction. Assistance can be rendered by the department in planning desirable facilities.

5. Consult selected bibliography for school shop planning materials on page 25.

C. Some Legal Functions

1. The State Department of Public Instruction has a dual role:

   a. Encourages creative and more effective planning of school facilities.

   b. Implements the Federally aided programs in the area of industrial education operating within the State.

2. School building laws require that:

   a. The State Department of Public Instruction approves all plans for new or remodeled schools.

   b. A registered architect or engineer be employed for all projects costing $15,000 or more to prepare plans and specifications and supervise construction.

   c. The heating plant must be located in a place which is not under any portion of the school building.

   d. Schools of more than one story must be fire resistant (basement is classified as one floor).

   e. State Department of Public Instruction and State and Local Fire Marshals must approve the use of any new building for school purposes.

   f. All spaces must be provided with adequate egress, at least two doors and several stairway accesses. (See page 18)

   g. Adequate fire alarm protection must be provided.

   h. Approval by the state office does not relieve the local officials of their responsibility, nor can it be substituted for it.

i. Once the working drawings and specifications are approved for construction, it is expected that the building will be constructed according to the drawings approved. Any changes from approved plans and specifications should be submitted to the Superintendent of Public Instruction for approval.

D. Determining Square Footage

1. The amount of square footage depends upon the number of factors such as:

   a. Type of shop

   b. Activities established in the curriculum

   c. Size and type of equipment

   d. The number of auxiliary areas needed, (stock and supplies storage, project storage, and planning).

2. Some general statements which have evolved through experience and which should assist in estimating approximate square footage necessary for school shops are as follows:

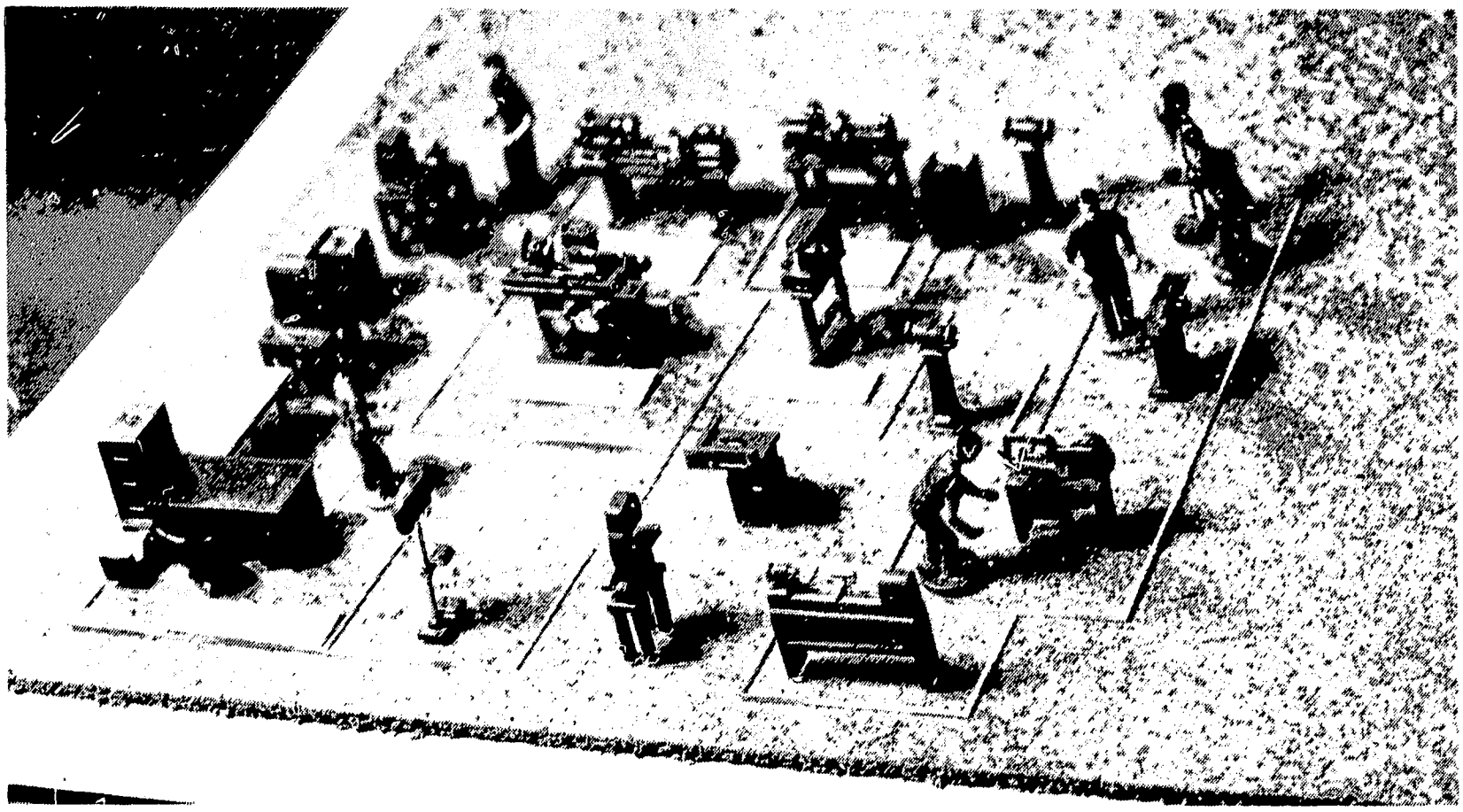
   a. A recommended formula is 100 square feet per student dependent upon the activities involved. Drafting and electronics might require less, while auto mechanics will require more space.

   b. Space for auxiliary areas connected with shops having machinery is in addition to the allotted per pupil square footage. (Approximately 20 percent of the total may be added.)

   c. Planning area and space for class discussion within the shop is necessary.

   d. Generally a facility which is rectangular in shape, with a length - width ratio of $1\frac{1}{2}$: 1, will prove more efficient.

   e. To assure that adequate space is obtained, a complete layout of equipment and auxiliary areas should be made as a guide to accurately computing the square footage desired.



Adequate Square Footage Can Be More Accurately
Determined with Three Dimensional Planning

E. Preliminary Shop Layout Procedure

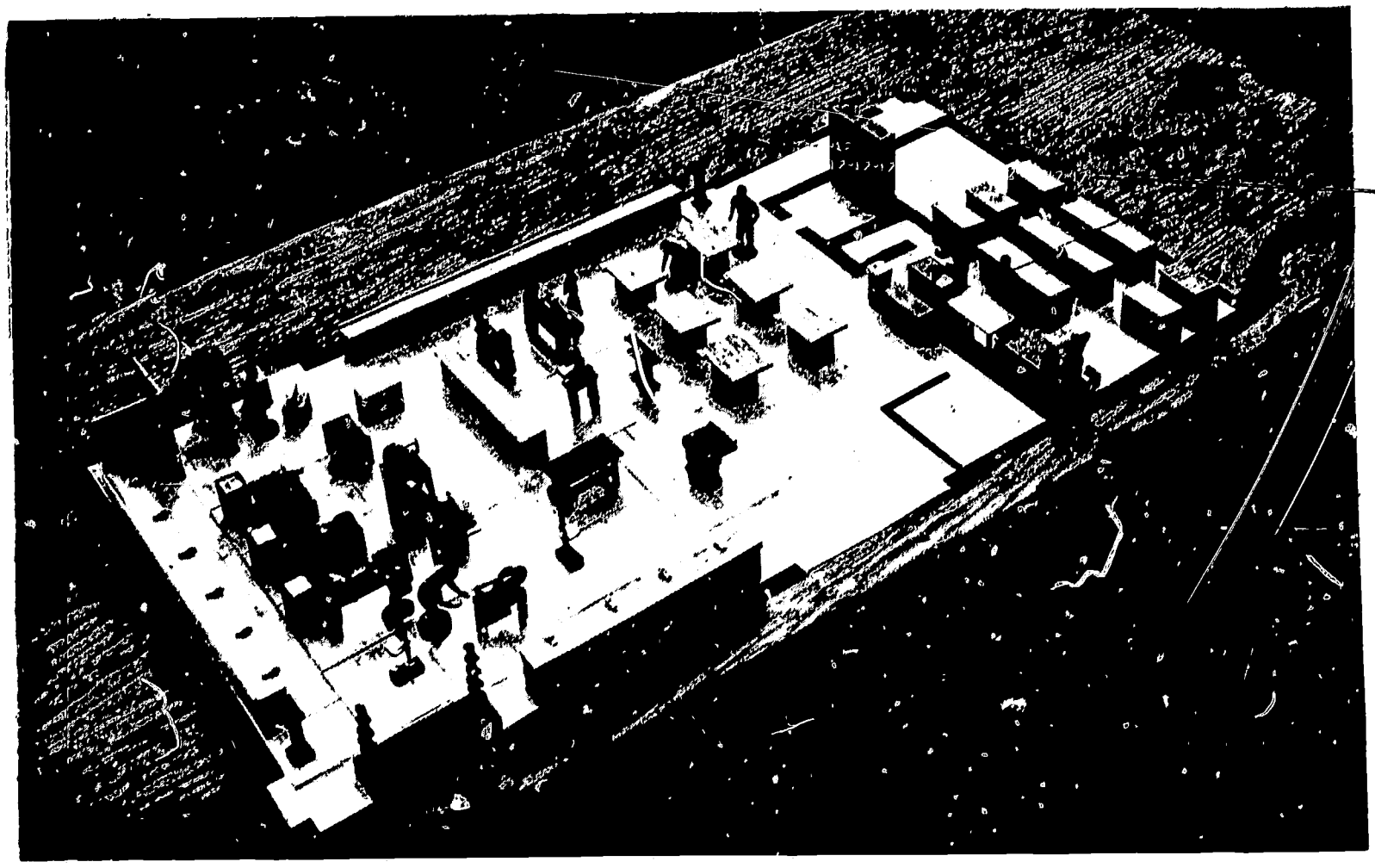
1. The drawing of preliminary plans may be carried out as follows:

   a. Templates or three dimensional models of the equipment should be selected for the desired activities ($\frac{1}{2}$" to 1' recommended scale).

   b. Tentative areas of activities should be established on cross-section paper.

   c. The equipment should be organized on cross-section paper to determine the most effective arrangement, size and shape of shop.

2. After the outline of the building or room has been determined and the preliminary drawing or sketch made, the location of windows and doors and other construction details should be considered. All utilities needed to service the laboratory or laboratories, such as electricity, ventilation, exhaust systems, and dust collectors should be incorporated in the overall plans.



The Plastic Based Models Permit Shop Planning With
A Safe Work Area Around Each Machine

F. The Final Plans

1. The location and physical arrangement of machines and other equipment must be known before preparing final drawings. Sufficient free wall space must be provided for such items as chalkboards, tool panels, and bulletin boards.

2. Adequate safety measures must be considered in all phases of planning. Acceptance and approval of the final plans must satisfy all requirements for safety as stipulated by the Department of Public Instruction, State Fire Marshal, and any local boards having jurisdiction.

3. The electrical engineer should be given enough information about the electrical requirements to plan adequately to meet present and future needs. It is important that flexibility be designed into the electrical distribution system. (See Page 22)

4. The completed building can be no better than the plans and specifications which are a part of the construction contract. These should be examined thoroughly before the building project is advertised for contractor's bids. It is better to make desirable changes before the contract is let.

5. Comprehensive specifications should be written for each piece of equipment requiring approval sheets. Specifications should then be

5. (continued)

carefully reviewed by competent members of the building committee before a purchase order is issued. Specifications should contain a description of appropriate safety guards, such as illuminated eye shields on power grinders and belt covers for exposed belts. All shop equipment should be equipped with the most reliable and effective safety equipment.

6. Adequate supervision should be provided during all stages of construction. On larger projects, the Board of Education should provide its own supervision to supplement that provided by the architect.

7. Final plans shall conform to <u>all</u> codes which apply to the facility.

G. <u>Architectural Service</u>

1. When the community planning committee has agreed upon a curriculum designed to meet the needs of youth and adults, the time is appropriate for the commissioned architect to proceed with the preparation of preliminary building plans.

2. Preliminary plans are simple line drawings representing the floor space desired and essential to providing adequate floor area for the program prescribed by the curriculum planning group.

3. At this point in the planning, the architect must know the precise space requirements of each curricular and related activities.

4. Corrections and revisions may necessitate compromises, but they must be considered on the basis of the total program.

SECTION II
INDUSTRIAL ARTS LABORATORIES

SELECTED TYPES OF GENERAL SHOPS

The physical facilities for general shops are determined by the kind of program desired, the grade level, and other factors as outlined in the topic "Determining Physical Facilities," (page 4) under subtopic, "General Principles."

The common types of industrial arts laboratories are:

A. Comprehensive General Shop

B. Limited General Shop

1. Graphic Arts
2. Wood and Allied Materials
3. General Metals
4. Power Mechanics
5. Electricity - Electronics
6. Drafting

Technological changes are having and will continue to have a great bearing on the kind and number of shop facilities to be considered when planning an industrial instructional curriculum.

Proper planning and organization of the new facilities will make it possible for the shop to serve a dual purpose. The general shop descriptions following may be organized to serve the needs of youth in industrial arts and the occupational needs of those who desire to gain depth of knowledge in an area to satisfy their vocational interests. The specifications recommended are the result of much study of successful operational plans and suggestions from individuals who have had experience in teaching in the separate facilities.

In each of the following descriptions of shop areas adequate space has been provided so that each student may have a work station. One area that may give the planner some concern is that of power mechanics when it is to serve the needs of youth who desire to increase their knowledge of the internal combustion engine. When designing this area the planner should give consideration to the number of live automobiles that will be serviced during the same class period. The need for clear traffic lanes will call for additional footage to maintain efficiency in operation.

COMPREHENSIVE GENERAL SHOP

This is understood to be a multiple purpose laboratory which may include activities in woodworking, metalworking, power mechanics, electricity-electronics, crafts, graphic arts, and drafting. Sometimes administrators will find it advisable, because of limited space, to have a shop serve dual purposes. A general shop carefully planned will provide this opportunity and save the cost of duplicating many pieces of equipment. These different activities are generally carried on in one room under one teacher. Space allotment for the shop area for twenty-four students might be 40' x 60' (approximately 100 square feet per student).

1. Laboratory may be divided into program areas as previously stated.

2. Provide for adequate spacing of equipment and the establishment of definite aisles of travel and plan for proper work flow.

3. A minimum of 12 foot ceilings is recommended with good accoustics and provision for ample air change. Special equipment may be needed to remove objectional fumes from specific areas.

4. A minimum of 100 foot candles of lighting on working surfaces should be provided. (See page 22 for specific lighting information.)

5. Floors should be of suitable tile or wood (not concrete).

6. Adequate provisions must be made for the following:

   a. Planning)
   b. Finishing)
   c. Project storage and display) See Pages 20-21
   d. Tool and supply storage)

   These provisions should be exclusive of basic space allotted to the laboratory area.

7. Electrical safety controls should be provided at each machine, and master relay operated control buttons should be located strategically. (See Page 22)

8. Utilities for specific areas within the comprehensive general shop should conform to those required for the respective unit shops.

WOOD AND ALLIED MATERIALS

This laboratory may include any of a number of activities dealing with products made of wood, ceramics, sheet metal, and synthetic materials including plastics. The materials may be used alone or combined. Space allotment for this shop area for twenty-four students might be 40' x 60' (approximately 100 square feet per student).

1. The laboratory may be divided into program areas such as:

   a. Woodworking
   b. Ceramics
   c. Metal Spinning
   d. Plastics

2. Adequate provisions should be made for planning, designing and fabricating products through hand and machine tool operations. Storage for stock, projects, supplies, and finishing should be provided. These areas should be exclusive of basic space allotted to the laboratory.

3. Facilities must be provided for dust control.

4. Lighting should be provided at a minimum of 100 foot-candles on working surfaces. (See page 22 for specific lighting information.)

5. Floors should be of suitable tile or wood. Where tile covering is used over cement base it should be resistant to oil and indentation.

6. Suitable access should be available for delivery of materials, supplies, and equipment.

7. Ceiling should have a minimum height of 12 feet and acoustical treatment of general area is recommended.

8. Electrical safety controls should be provided at each machine and master relay operated control buttons should be located strategically. (See Page 22)

9. Careful consideration should be given to planning the finishing area. (See Page 20)

GRAPHIC ARTS

This laboratory is not to be confused with a print shop. A variety of activities should be included such as printing, photography, paper making, book binding, and silk screen printing.

There is a definite relationship of locations of equipment to provide a logical traffic pattern in the shop. Space allotment for the shop area for twenty-four students might be 40' x 60' (approximately 100 square feet per student.) Drafting and graphic arts may be combined where a limited program is planned.

1. Laboratory may be divided into program areas such as:

   a. Planning
   b. Paper storage and cutting
   c. Composition and letter press work
   d. Silk screen and duplicating
   e. Darkroom and photography
   f. Bindery
   g. Papermaking
   h. Etching and engraving presses and intaglio work
   i. Lithograph presses and planographic work

2. The nature of the work in the graphic arts room will justify special attention in designing the heating and ventilating system to avoid direct currents of air on materials and work in process.

3. A minimum of 100 foot-candles of lighting on working surfaces should be provided. (See page 22 for specific lighting information).

4. Floors should be of suitable tile or wood with concrete bases for heavy equipment.

5. Presses should be mounted on vibration absorbing blocks.

6. Darkroom should have light lock doors or suitable light traps, incandescent lights, and sinks with lead traps. (Consult manufacturers of photographic supplies for assistance.)

7. Electrical safety controls should be provided at each machine and master relay operated control buttons should be located strategically. (See Page 22)

8. Adequate provisions exclusive of the basic space should be made for the following auxiliary areas:

   a. Planning
   b. Display
   c. Student storage
   d. Paper, tool, and supply storage

   See Pages 20-21

POWER MECHANICS

This laboratory may include a wide variety of activities such as: hydraulics and pheumatics; internal and external combustion engines; and gear, pulley, and other drive mechanisms used for power transmission.

Space allotment for this shop area for twenty-four students might be 40' x 60' (approximately 100 square feet per student).

1. A ground floor "drive-in" access through garage type overhead doors should be provided.

2. Adequate open work area in front of the drive-in access should be provided as a work and instructional area. Drainage should be provided.

3. Grease and sand traps should be provided in the drainage area.

4. Water and air must be available. Air should be supplied at 150 P.S.I. and 16 C.F.M.

5. Good ventilation and an exhaust gas venting system must be provided.

6. Floors should be of concrete and should provide adequate floor drainage.

7. Lighting should provide a minimum of 100 foot-candles on working surfaces. (See page 22 for specific lighting information.)

8. Provision should be made for planning and lecture demonstration area.

9. Storage must be available for teaching aids and devices and assemblies under repair.

10. A minimum of 12 foot ceilings is desirable.

11. An arranged area for equipment such as a frame hoist, a drill press, welding equipment, lathes, grinder, and arbor press should be planned.

12. Bench and stand areas are required for small internal combustion engines, (live) short auto chassis, outboard motors, hydraulic and pneumatic equipment, and power transmission.

13. Electrical safety controls should be provided at each machine, and master relay operated control buttons should be located strategically. (See Page 22)

14. When this same facility is to serve as the automotive shop, additional space should be included as work areas for live automobiles. (See Standards, Automobile Manufacturers Association, listed page 26.)

15. At least one single post hydraulic hoist should be included in an automotive shop.

GENERAL METALS

This laboratory may include any activity pertaining to metals. Space allotment for this shop area for 24 students might be 40' x 60' (approximately 100 square feet per student).

1. Laboratory may be divided into program areas such as:

   a. Sheet and art metal
   b. Forging and heat treat
   c. Foundry
   d. Welding--oxy-acetylene, arc, and inert gas
   e. Metal machining
   f. Plating and related processes

2. Adequate provisions should be made for planning, designing, and fabricating products through hand and machine tool operations. Storage for stock, projects, and supplies should be provided. (See Page 20)

3. Location on the ground floor or on a properly stressed floor suitable for future program changes is necessary. Floor should be wood in all areas except the hot metals.

4. Suitable access for delivery of equipment and supplies is needed.

5. Minimum of 12 foot ceilings, good acoustics control, and ample air change to eliminate objectionable smoke or gases should be provided.

6. Special equipment for health and safety may be needed in areas such as welding, heat treating, and plating.

7. A minimum of 100 foot-candles of lighting on working surfaces should be provided. (See page 22 for specific lighting information.)

8. All machines should be bolted to floor or mounted on a shock absorbing block.

9. Adequate provisions must be made for the following auxiliary areas:

   a. Tool and supply storage
   b. Project storage
   c. Planning
   d. Display

   See Pages 20-21

10. Electrical safety controls should be provided at each machine and master relay operated control buttons should be located strategically. (See Page 22)

11. The electrical distribution system should be designed with the capacity and flexibility to provide for present and future needs. (See Page 22)

12. Careful consideration should be given to a metal finishing area.. (See Page 20)

ELECTRICITY-ELECTRONICS

This laboratory is intended for the study of electrons, ions, and other particles, the physical phenomena derived therefrom and the application of this phenomena. Space allotment for this laboratory for 24 students might be 40' x 40' (approximately 60 square feet per student).

1. Laboratory should provide service facilities for all facets of the electricity-electronics program.

2. A minimum ceiling height should be that of the standard classroom and effective acoustical treatment is recommended.

3. A minimum of 100 foot-candles of lighting on working surfaces should be provided. (See page 22 for specific lighting information.)

4. Ventilation and full air conditioning should be provided. Specialized areas may require exhaust systems to remove dangerous and noxious fumes.

5. Utilities should be air, water, gas, electricity 115 a.c. and 220 a.c., and a sewer. Antennas for A.M., F.M., T.V. for broadcast and reception should be provided.

6. Lecture, demonstration and audio visual facilities should be provided.

7. Ground potential and capacitive mass materials should be reduced to a minimum.

8. Adequate power and signal distribution should be provided at each work station.

9. Controlled storage should be available for:

   a. Student work
   b. Parts and supplies
   c. Equipment (student)
   d. Equipment (teacher)

10. Provisions for fabrication of parts, chassis and other items are desirable. A limited but complete panel of hand tools, small sheet metal machines, drill press, lathe, grinder and work bench are recommended.

11. The planning and resource area should include:

    a. Reference books
    b. Periodicals
    c. Teaching aids
    d. Technical materials

12. Adequate safety control and equipment protection should be provided through the use of:

    a. Fuses
    b. Switches
    c. Isolation transformers
    d. Relays

13. Non conducting type extinguishers and first-aid facilities should be available in the laboratory.

14. All machines and equipment should be mounted and treated according to specifications for such machines and equipment.

DRAFTING

This laboratory may include any of the creative and communicative aspects of drawing. Space allotments for this laboratory area for 30 students might be 40' x 50' (approximately 60 to 70 square feet per student).

1. The program may include areas such as:

   a. Sketching and perspective drawing
   b. Problem approach to creative design
   c. Map, graph, and chart making
   d. Mechanical drawing
   e. Architectural drawing
   f. Development of surfaces

2. Provisions should be made for a work area with light equipment to build small models, experimental structures, and perform auxiliary activities such as air brush work, rendering in color, and duplicating.

3. Storage for models, teaching aids, and supplies should be provided.

4. Provisions for exhibiting creative class products and instructional material should be provided.

5. A minimum of 100 foot-candles of lighting on working surfaces should be provided. (See page 22 for specific lighting information.)

6. Minimum ceiling height should be that of the standard classroom including effective acoustical treatment.

7. Adequate auxiliary space with hot and cold water should be provided for the duplication of drawings and prints.

8. Washing facilities should be included.

9. Main travel aisles must be wide enough to allow free passage.

10. Provisions should be made for industrial drafting equipment.

11. Drafting rooms should be provided with facilities for reproduction of drawings. Special electrical and ventilating equipment may be needed.

SECTION III
SHOP ARCHITECTURE

GENERAL CHARACTERISTICS

Size and Shape

The shop areas should be of sufficient size to house the activities selected. It is recommended that the shop be rectangular in shape, preferably a ratio of 1 : $1\frac{1}{2}$ as to width and length. While the floor area will vary with the type of shop, the activities selected, and the auxiliary rooms needed; it is recommended that the width of the room should not be less than 40 feet. Areas for auxiliary and storage spaces are not included in the recommended square footage stated in the description for the various laboratories and shops. For those shops requiring considerable equipment, a rectangular area of a size 40' x 60' has received wide acclaim and functions well.

Ceilings

Shop ceiling height for maximum efficiency depends upon the type of shop, but minimum for all shops is generally conceded to be about 12 feet. If balcony storage is designed within the shop, the ceiling height should not be less than 14 feet. Electricity-Electronics and Drafting Laboratories are exceptions.

Exits

Shops should have at least two exits, preferably at opposite ends of the shop. These two exits are in addition to any large overhead door installed for project or machinery movement. Exits should be approved by the local Fire Marshal.

All doors should open outward and be recessed where opening of the door projects into a hall which is used frequently for student travel.

All shops must be provided with easily accessible fire exits.

Security for all laboratories must be provided.

Displays and Decorations

Lighted exhibit cases should be provided in the shop and in a central location in the principal part of the building.

One or more bulletin boards and chalkboards should be provided in each shop. The size of these will be determined by the space available.

Pleasing color of walls and ceiling not only contribute to safety, but also to the general atmosphere of well being and good housekeeping.

Visual Aids

Most visual aids require the use of a darkened room and for this reason it is important to consider ways and means of planning for this kind of instruction. In many schools, one room may serve as a planning and instruction area and include the necessary provision for providing visual aids.

Windows

Natural light should be used to the fullest advantage wherever possible. Window area combined with bilateral lighting and overhead lighting make for the best conditions. Make full use of natural lighting; however, provisions should be made to control excessive brightness from sky, adjacent buildings, or direct sunlight.

AUXILIARY ROOMS AND FACILITIES

Auxiliary rooms, such as planning, finishing, and storage rooms, should be divided from the main work areas by a glass partition, so that the teacher can readily observe the activity in that room.

Planning Rooms and Demonstration Areas

The planning area or room should be a part of the shop set off from the work areas by a glass partition. It should provide for storage of books, drawing or sketching supplies, and visual aids equipment. It is an area where discussions and planning may be done. The size of the room will be determined by the number of students who may be using it at any given time. It is a logical space to place the teacher's desk.

The planning area should be located in a space which lends itself to easy supervision. Chalkboard, tables, and adequate seating facilities should be provided in this area.

Finishing Room

Where practical, a heated room should be provided adjacent to, or within the shop, where projects can be finished. This room should be designed to retard spread of fire. It should be equipped with metal cabinets for storing finishing materials. It should be dust proof if good results are to be expected. A forced air exhaust system is necessary. This room should be approved by the local Fire Marshal. Surfaces of table tops or work benches should be of a material which is easily cleaned. Utility sink with clean-out trap should be provided.

Tool Storage

Decentralized tool panels which conserve space and increase the efficiency of dispensing and returning tools for storage are recommended. Types incluae wall panel, both open and closed; portable units on casters and general tool storage. Panels that lock are most satisfactory. Tool storage should be close to the place where they are to be used to ease the flow of traffic. Tool holders should be made to accommodate only the tools for which they are made. All holders should be designed to hold tools securely. Precision measuring instruments should be locked in special tool cabinets. Cutting tools and pointed tools should be racked or mounted safely.

Storage Rooms

Every shop or group of related shops should have supply storage facilities; the size to be determined by the nature of the shop work, the number of students,

and the type and quantity of supplies to be stored. Recessed storage cabinets are desirable where building conditions permit. Storage rooms should be located to permit direct delivery or be near the receiving points.

Office

In shops where sufficient space is available provision should be made for an office of adequate size to accommodate a desk, filing cabinet, shelves for reference material and storage of personal effects. Where space is limited this office may be a part of the area designated for instructional planning.

Student Lockers

Individual lockers for the storage of clothing, aprons, and small projects should be available. Under-bench areas should be utilized for locker space.

HEATING, VENTILATING, AND DUST COLLECTION

Heating and ventilating systems should maintain comfortable and healthful conditions at all times. Dust, odors, fumes, and gasses should be removed by an adequate exhaust system.

Exhaust systems are needed to (1) reduce fire hazards, (2) increase visibility, (3) reduce housekeeping costs and aid in housekeeping, (4) aid in purifying the air in the working area, which is important to health, and (5) encourage interest in industrial arts.

In rooms where activities produce gases and fumes, an efficient forced-air exhaust system is needed. The exhaust system should not direct the fumes toward the windows of an adjacent building.

Installation of a dust exhaust system is necessary where dust creating activities may hamper some types of work in other sections of the shop. In some instances individual dust collection may be provided for each machine.

LIGHTING AND ELECTRICAL

Natural lighting is not a simple problem. The objectives of letting daylight into the room and at the same time keeping high brightness from the eyes of the occupants who may be facing in any direction seem to be conflicting ones. It is also desired to equip the room so that control of brightness will not be a continual responsibility of the teacher.

Artificial lighting systems should produce a uniform distribution of shadow free and glare free illumination. It is generally accepted that a minimum of 100 foot-candles, at work space height from floor, is required for mechanical work at benches and machines. More important than intensity is visual comfort and efficiency, based on balanced brightness. Unshielded tubes or bulbs should never be used. Specially located lighting may be needed in certain areas or on certain machines. If flourescent lighting is used, the fixture must be designed to prevent the stroboscopic effect whereby moving wheels or gears may appear to be stationary. Professional advice from an illuminating engineer is recommended.

The electrical service should be within the prevailing voltage limits in the area. Careful checking on the available voltage and the voltage of motors on the machines to be installed will prevent the necessity of installing expensive special lines.

Power and light controls should be centralized on a locked master control panel, with pilot light, and located near the teacher's desk or office. Master emergency throw-out push button switches should be located at strategic points about the shop. It should be possible to secure all shop power with lock and key. A central control panel should be conveniently located. All machines should be individually fused.

It is imperative that ground connections be provided for all motors. A three-wire service is best or each motor should be grounded. The local electrical code should be followed in installing all power lines.

Sufficient three-prong polarized, grounded outlets should be located approximately ten feet apart and forty-two inches above the floor.

Electrical distribution panels should be of the circuit-breaker type with adequate circuits to provide for expansion or increased power needs.

The capacity of a wiring system must be determined accurately for reasons of safety and economy. The original cost of a wiring system is but a small fraction of the total building cost, but its inadequacy can prove very distressing and expensive. The distribution system should be designed for flexibility.

Vapor proof lights and switches should be provided in areas where combustible gas or vapor may exist. Underwriters Laboratory approved magnetic switches should be used on all machines.

All installations shall conform to the requirements stated in the current edition of the "National Electrical Code" except where local codes supercede or exceed the requirements of the National Code. A professional electrical engineer should be consulted.

PLUMBING

Every shop should have a drinking fountain located where it will not cause congestion but still be in full view of the teacher.

One or more floor drains are desirable if any activity will require water or scrubbing of the floor to maintain cleanliness.

Adequate and convenient toilet facilities should be provided.

Adequate gas service should be made available to each shop area being planned. The local service company should be consulted.

Hot and cold water should be available with adequate wash-up facilities.

Shops that are planning work with a variety of wet faucets should install the needed shut-off valves and lines as a part of the original plumbing. These may be installed on the wash-up sink.

SOUNDPROOFING

Shops should be acoustically treated to reduce reverberation and transmission of sound to other areas. Transmission occurs through duct work and structural members and may be reduced by: (1) Proper location of shop, (2) Proper treatment of ducts if they are a part of the general building ventilation system, (3) Proper treatment of structure, and (4) Proper mounting of machines. Sound proofing should be designed by an acoustical engineer.

FLOORS AND FLOOR COVERING

The selection of flooring materials depends on the particular activities for which the area is designed. Safety plays a big role in the type of floor - safe to walk on, safety in work areas, impervious to solutions, retard tool breakage, fire safe, and easy to repair. Asphalt tiling over a concrete base is a safe, economical floor and covering for a drafting, electronics and crafts room; but for shops which house heavy equipment, wood block flooring may be the safest and most economical over a period of time. In each, flooring and floor covering should be selected to meet the needs of the area.

PLACING EQUIPMENT AND TYPES OF EQUIPMENT

A work area of sufficient size to permit the assembly of large projects must be provided. The size of this area will vary with the type of activity selected. All parts of the shop should be visible to the teacher at all times.

Safety should be considered when arranging equipment. Arrange groups of dangerous machines away from the aisles and routes used by students.

Equipment and work stations should be arranged to provide operating space. Adequate space should be provided at each machine for minor maintenance operations.

Tools and equipment should be located near the center of the activity which they serve.

Machines commonly used in sequential order or on a production basis should be placed in the order of their operation with a minimum of travel between them.

Special equipment such as monorails, lifts, and engine exhausts must be carefully planned for proper location, size, shape, and capacity.

SAFETY AND OTHER CONSIDERATIONS

The floor space must be adequate for the benches, machinery, and working space for each student.

Machinery must be placed where it will not endanger students due to moving parts or other hazards of particular machines.

All gears, belts, and other moving parts must be guarded wherever possible.

Proper ventilation is necessary for the health of the students. Where necessary to eliminate a health hazard, dust collectors should be provided for such machines as grinders, circular saws, surfacers, and sanders.

Adequate lighting is an important safety factor in any school shop. Prevention of eye strain and fatigue is necessary for good operational procedure on machines.

All electrical wiring should conform to the national, state, and local codes.

Approved safety metal storage containers must be provided for all used rags.

Proper storage of supplies and projects is one of the most important safety factors. Combustible materials such as paints, lacquers, oil, grease, and rags must be stored in fireproof spaces.

The type of floor is important; it should not be slippery. This is especially important in the area around machines. High quality non-skid material is available for application on work areas. (See Page 23)

Pleasing color of walls and ceiling not only contributes to safety, but also to the general atmosphere of well being and good housekeeping. The use of color has become a very important factor in making the shop a safe and cheerful place in which to work. Consult your local paint representative for the latest information in this field.

A first aid cabinet should be placed in a central location and readily accessible.

All shops must be provided with easily accessible fire exits.

Due to shop noise, it is essential to have fire alarms located so that all people in the shop hear the alarm.

Fire doors and fire walls should be used where necessary. Check the state code on fire regulations.

No combustible ceiling tile may be used in two story construction.

SUMMARY

All planning should be carefully reviewed to make sure the shop facilities will provide for the activities established in the educational curriculum.

All of the plans should be checked carefully with the planning lists and changed where modifications seem desirable.

The drawings should be usable by the contractor or architect in arranging the rooms and conveniences desired. These are the shop plans and should be based upon the educational phase of the planning and developed by the planning committee.

The specifications giving details of construction, types of material to be used, and other construction details should be clearly listed and should be checked carefully by the administrative officers, the architect, and the contractor.

All planning and drawing of specifications should be a cooperative undertaking by all interested persons and groups.

When working out complete details of the plans, such things as room arrangements, locations of equipment, locations of outlets for electricity, water and gas should be indicated on the drawings.

Purchasing tools, supplies, and equipment is in itself another unit of study. Writing specifications, securing bids, and purchasing is a tremendous task. School shop equipment demands good quality and specifications in many instances different than those required in industry.

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SAMPLE SPECIFICATION - COURTESY OF DETROIT PUBLIC SCHOOLS

GENERAL CONDITIONS AND SPECIFICATIONS FOR MACHINE TOOLS

1. NOTICE TO BIDDERS

1.1 General Conditions - The following conditions are to be observed, except when otherwise specified, and will influence the awarding of contracts for machine tools and attachments.

1.2 Accessories, Attachments and Fittings - The attachments and accessories which are to accompany each machine are specified in connection with each machine's specification. However, it is understood any minor fittings shall be included so that the machine shall be complete and ready for operation.

2. GUARDS

2.1 Requirements - All machinery hereinafter mentioned shall be provided with guards for all belts, pulleys, gears or other moving parts as required by the Michigan Department of Labor and in accordance with commonly accepted safe practices. All guards are to be substantially built, with heavy guage sheet metal or castings preferred. Guards shall be so constructed that they may be easily removed for repairs or adjustments on the machine; fastening devices such as hinges, catches and similar positive arrangements shall be provided to hold the guards in place.

3. MOTOR AND ELECTRICAL CONTROLS

3.1 National Electric Code - All work in connection with mounting and connecting of motors, controls and accessories shall comply with the requirements of the National Electric Code.

3.2 NEMA Rating - Motors shall be of sufficient capacity to operate the machine under maximum load without overheating. The motors shall have a NEMA rating of (a) 40° Centigrade rise under continuous use for metal-working machines - (b) 55° Centigrade rise under continuous use for woodworking machines.

3.2.1 Three-phase Motors - All motors of 1/2 H.P. and larger shall be AC 3-phase, 60 cycle, 230 volt, unless otherwise specified.

3.2.2 Small Fractional Horsepower Motors - All motors of 1/3 H.P. and smaller shall be AC single-phase, 60 cycle, 110-220 volt circuits except where otherwise specified.

3.3 Motor and Control Wiring - The motor and control on each machine shall be completely wired, all switches and controls fastened in place. Suitable provision shall be made for connecting the machine to the power circuits in a school shop. The wiring shall be with type "T" wire with galvanized rigid conduit, flexible conduit or "Thinwall" conduit, installed in a neat manner and the line shall follow the contour of the

machine surfaces. The Board of Education will connect the machine to the power circuits.

3.4 Enclosed Motors - Motors furnished on woodworking machines shall be of the totally enclosed type.

3.5 Magnetic Switch Type Installation - The control equipment on motors of 2 HP or less, on which the magnetic switch type installation is called for, shall be Square D Class 8536, Allen Bradley Bulletin 709, Clark Controller Bulletin 6013, Cutler Hammer Bulletin 9586, no substitutes. They shall have general purpose enclosure with separately mounted control stations, except that "Start-Stop" buttons may be mounted in the magnetic starter cover if mounted in a convenient location for the machine operator and further provided that no operating feature of the machine is impaired.

All machines requiring motors larger than 2 HP shall be equipped with a non-fusible combination starter Square D Class 8538, Clark Controller Bulletin 6018, Cutler Hammer Bulletin 9589, Allen Bradley Bulletin 712, general purpose enclosures, no substitutes. Push button control stations shall be mounted separately.

3.6 Manual Switch Type Installation - The control equipment on all machines on which the manual switch type installation is called for shall consist of a manual starter, "across the line" "lockable stop button" type with overload relay units. These units to be resetable without removing the starter cover Square D Class 2510, Allen Bradley Bulletin 609, Cutler Hammer Bulletin 9115.

Where it is necessary to mount the overload relay units separate from the push button station, a manual type, horsepower rated push button - Delta #15-811, or Cutler Hammer #9115 H83 - with a separately mounted lockable switch and overload unit - Square D Type AG7 or Cutler Hammer #9115H81 - may be used in lieu of a self-contained manual starter by permission of the Vocational Department of the Board of Education.

All 120 volt machines shall be provided with a 3-wire cord not less than eight feet long and a 3-wire grounding type cap - Bryant #5666 or Hubbell #5267.

3.7 Control Stations - Control stations (stop and start buttons) shall be mounted in a convenient location for the operator.

3.8 Reversing Controls - In the case of machines which require that the motors run in either direction, controls shall consist of starters, overloads, push buttons, switches, etc., as required in paragraph 3.5 or 3.6 (whichever is specified - magnetic or manual controls) and in addition to these controls shall have a horsepower rated, drum type, reversing controller Cutler Hammer Catalog Number 9441, Clark Bulletin 141, Allen Bradley Bulletin 350 or Square D Class 2601.

3.9 Portable Electrical Equipment - Portable electrical equipment such as electric drills, portable sanders and the like are to be supplied with number 16, 3 conductor type S dreadnaught cable. The extension plugs are to be provided with ground terminal for grounding purposes. Cap shall be armored cord grip type Bryant #5264 or approved equal.

3.10 Voltage of Portable Electrical Equipment - It is agreed that no portable equipment is to be provided with over 155-V motors, that is, no portable equipment is to be purchased for 220-V circuits.

3.11 Motor Bearings - Motor bearings shall be of the sealed anti-friction type.

4. DELIVERY

4.1 Conditions of Delivery - In making delivery no door casing or other structural part of the building shall be altered or removed without specific arrangement with the Business Manager's Office. Quoted price shall include delivery to the specified room in the designated school.

SAMPLE SPECIFICATION - COURTESY OF DETROIT PUBLIC SCHOOLS

DEPARTMENT OF VOCATIONAL EDUCATION SPECIFICATION NO. 64

School_____

No. Required_____

Room No._____

SAW, METAL CUTTING BAND

1. CLASSIFICATION

1.1 Type - This specification covers a light duty horizontal metal cutting band saw.

2. CAPACITY

2.1 Specific Minimum Requirements

Machine to cut rectangular stock not less than 3-1/2" x 6-5/8".
Machine to cut round stock not less than 3-1/2" diameter.
Machine to have not less than three blade speeds - range 54 to 190 f.p.m.
Driving motor - 1/6 H.P.

3. MOTOR AND ELECTRICAL CONTROLS

3.1 Specifications - The motor characteristics and electrical controls must conform to the General Specifications, Paragraph #3. Machine to be driven by 1/6 H.P. (or larger) single phase, capacitor type, ball bearing motor equipped with toggle-type cut-off switch designed to automatically shut off saw at completion of each cut.

Motor: 120 volt; 1 phase, A.C.

Switch: Magnetic

4. GUARDS

4.1 Specifications - All pulleys, blade wheels, and belts to be fully guarded as provided for in General Specifications, Paragraph 2. Belt guard to be hinged to permit easy access to belt-changing area.

5. REQUIREMENTS

5.1 General - All parts of the hand saw shall be new, or the latest approved design, and of first-class commercial quality. Insofar as practical, the machine shall be the manufacturer's current production model, as previously manufactured, and placed in successful operation.

5.2 Frame - The frame shall be of welded steel construction with tublar steel base. Saw to be equipped with screw feed-type blade tension adjustment.

5.3 Vise - The vise shall be of the quick-acting type having angular adjustment on the front jaw.

5.4 Saw Guides - Saw guides and wheels shall be of ball-bearing type.

5.5 Blades - Machine to be furnished with six 1/2" metal cutting blades.