WELDING AS A MEDIUM OF INSTRUCTION FOR INDUSTRIAL ARTS

by

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CHAPTER I

INTRODUCTION

The basis for a powerful nation lies in geographic position, people, food, and raw materials, especially oil, coal, and iron. Any nation with suitable climate, tillable soil, long coastline, resources, and a people whose mission is democratic development for the benefit of all is a leading power. No nation can be great today without coal and iron and the technology that goes with using these minerals. We are living in a metal age which is constantly expanding with new developments, processes, weapons, machines, and tools beyond the layman's conception. Our standing in the world depends on how rapidly and skillfully our scientists, physicists, and engineers can invent, design, and assemble materials from the ores of the earth. The problem facing the average person today is to keep pace with our inventors, to understand the products of modern industry, and to be able to use, on the job or at home, the tools, techniques, and processes of industry.

The American people, including laborers, semi-skilled and skilled workers, were not prepared educationally for employment in the industries set up by the
Defense Production Program for World War II. After new factories were constructed and old factories re-tooled, there was such a shortage of skilled men that it was necessary to re-educate thousands of people before they were prepared to work efficiently with modern tools and machines in up-to-date factories. A great many skilled artisans who came directly from schools, apprenticeships, and various jobs had to be refreshed and informed of the latest developments in modern production. The fact that so many people, young and old, had to be re-educated to fill these industrial positions is evidence of a growing need for closer relationship between schools and industry. (For statistics, see Appendix B)

Since the development of welding and cutting metals with an oxyacetylene flame, in the early part of the twentieth century, the process has played an important role in the industrial development of this country. Today welding is essential to TRANSPORTATION, in the assembly of ships, airplanes, tanks, automobiles, and trains. In CONSTRUCTION, welding is indispensable in the building of machinery, canals, pipe lines, tunnels, bridges, and factories. Welding is required for POWER production in building dams, spillways, gates, locks, and power plants. For FOOD PROCESSING, there is great use for welding in the assembly of tanks, steam cookers,
peeling and pitting machines, and vats of corrosive-resistant metals.

World War II brought about the greatest advancement of all time in the technology of cutting and fastening metals by oxyacetylene and electric processes. Now steel can be cut or welded under water, and the welding of virtually all metals has been perfected to produce flawless joints in a minimum of time.

The tremendous demand by the war defense program for rapid production of fabricated metal goods in large quantities brought welding into a key position as an essential process. Both men and women were trained to do production-line work on specific jobs, and, along with thousands of other workers in related duties, they realized the importance of welding in manufacturing. A few years prior to the war, welding was an expensive process, harmful to the eyes, and performed only by a few highly skilled mechanics. Widespread instruction in welding processes for use in construction of the machinery of war has educated the general public in the importance of metals and their uses in preserving the American way of life.

Industry is becoming increasingly complex, with new machines, new metals, and a new technology, while a good many secondary schools continue to teach "manual
training," consisting primarily of courses in woodworking, overlooking the fact that metals and their alloys are most important for the protection, satisfaction, comfort, and well-being of the American people.

Statement of the Problem

It is the purpose of this study to determine whether or not welding should be included in the industrial arts curriculum of modern secondary education. With the ever-changing trends of industry, it is difficult for one person or even one institution to decide, without some research, just what courses should be offered in the industrial arts program. Some high schools have included welding in a unit shop program; others consider it only as a part of a general shop program. A great many schools do not consider welding important enough to include the work at all. The aim here is not to design a complete plan for all situations, but rather to discover if there is a universal need for welding as a phase of industrial arts instruction in the secondary schools and what type of instruction should be offered.
Sources of Information for This Study

The data for this study have been collected from the following sources:

2. Questionnaires sent to two hundred California secondary schools.
3. Questionnaires sent to sixteen superintendents of California's largest school districts.
4. Correspondence with leading industrial arts educators throughout the United States.
6. Correspondence with the largest manufacturers of welding equipment.
7. Study of technical literature and professional publications in the field of industrial education.

Methods and Procedures

From a study of articles and books written by leading industrial arts teachers, educators, and supervisors, several quotations were selected as indicative of the philosophies and objectives of general education and as
a means of showing the field of service of industrial arts in the secondary schools. The next action was to thoroughly analyze welding with its related work in the light of the ideals set up by these leaders, in order to determine whether this subject offers the opportunities and situations necessary to accomplish the aims of modern education. After a consideration of whether or not the fabricating of projects by cutting and joining metals with arc or flame is in agreement with educational objectives and should be a part of the industrial arts training program, a suggested general course of study was formulated and has been included in the appendix of this study.

A survey was conducted by a questionnaire, prepared and sent to the industrial arts teachers in the secondary schools of California. This form consisted of questions and space for comments on the subject of welding instruction. The responses provided reasonably accurate information as to the amount and type of instruction currently offered. The responses also gave the general opinion of teachers on the job, the amount of welding equipment available in the school shops, the amount of money budgeted, the type of work students perform, and the community need for welders.

A second questionnaire was sent to superintendents
and administrators of school districts throughout the state. They were requested to state their opinions in regard to the need for welding instruction.

A third questionnaire was distributed to the leading manufacturers of welding equipment throughout the United States, requesting information and suggestions about the planning of the welding shop, type of equipment, its maintenance, and its cost. These concerns were asked to state their opinions and to return any educational or visual aid materials available for school use. Instructional materials submitted are listed in the appendix.

Scope and Probable Value of This Study

This study has been conducted within the state of California, which has a school system and an industrial plan unlike that of any other state. To determine the need for such an industrial program in another state would possibly require a similar study of its school program and its industries as a basis of recommendation.

It was necessary to go outside of California for information from some manufacturers of welding equipment, and to gather opinions of leading educators from various parts of the United States. The latter were selected mostly from the trustees or national officers of Epsilon
Pi Tau, national professional honor society in industrial arts and vocational industrial education.

The results of this survey should be of value to teachers of welding and metalwork in California and to those schools which are planning to build new industrial arts laboratories, especially since there is no published state course of study on the subject, nor is there a state director of industrial arts to lend comparable guidance. The study aims to set up minimum standards for floor space, type, quantity, and condition of equipment, and quality of instruction in order to familiarize teachers with the minimum requirements in such matters.

Limitations of This Study

The geographical limits of this research are the boundaries of the state of California, corresponding with the purpose of the study, which is to evaluate generally throughout that state the importance of welding in the program of California's secondary schools. The schools which offer an industrial arts program provided the bulk of the information, and it is with this type of education that the study is primarily concerned. No attempt has been made to evaluate the vocational training program, nor to consider vocational work in conjunction with industrial arts.
The questionnaires used as a means of securing information were, on the whole, objective. They were designed to be answered by checking or completion. The responses could be objectively weighed to produce data which would be as reliable as the people who participated. The ideas and remarks gathered are purely subjective and could only be summarized for general conclusions.

The course of study presented in the appendix has been prepared as a suggested outline for school use, not as a complete program for any particular school. This plan has been formulated by one person, the author, following teaching experience, knowledge of California schools, and thorough analysis of the survey data and opinions collected. Had a greater number of qualified persons aided in the construction of this course plan, the reliability would be improved.
CHAPTER II

MODERN EDUCATION AND INDUSTRIAL ARTS

The objectives of secondary education are far beyond the scope of this study. However, some objectives should be mentioned to complete the picture of the purpose in offering welding instruction as a means of fulfilling industrial arts objectives, which in turn add more of life to a well-balanced, liberal or "general" education. The purpose of the whole of education has been published in several statements of the National Education Association and publications such as Frederick G. Bonser's "Efficient Education" (2:p.95).

No attempt is made here to justify industrial arts, but the aim is to show the part that industrial arts takes in satisfying "The Seven Cardinal Principles" as stated by the United States Office of Education (13:p.285):

1. Health
2. Command of fundamental processes
3. Worthy home membership
4. Vocation
5. Civic education
6. Worthy use of leisure time
7. Ethical character

Industrial arts contributes to the "Health" principle in the following connections:
1. Manipulative skill development
2. Safety training with tools and machines
3. Driver training
4. Precautions in protecting eyes
5. Precautions in protecting lungs
6. Precautions in protecting skin
7. Plumbing and sanitation

The "Command of Fundamental Processes" principle refers primarily to the three R's which can be given more meaning with experience in the following:

1. Shop arithmetic
2. Shop layout and blueprints
3. Geometry of mechanical drawing
4. Graphic arts
   a. Printing
   b. Lettering
5. Shop vocabulary

"Worthy Home Membership" as developed through books and in an academic classroom is rather abstract without the concrete experiences given boys and girls in such industrial arts areas as:

1. Home planning--designing and furnishing
2. Home repairs and upkeep
3. Power--heat and light appliances
4. Transportation--buying and maintaining
5. Communication--printing, telephone, telegraph

The principle of "Vocation" would probably mean a successful trade to a person not familiar with the U. S. Office of Education's interpretation of vocation in this sense. The bulletin states (13:p.13), "This ideal demands that the pupil explore his own capacities and attitudes, and make a survey of the world's work, to the end that he may select his vocation wisely." That is a definite purpose of industrial arts -- to explore basic industrial occupations and their processes, tools, and materials -- for a better understanding of our world. Such experiences are offered in the following:

1. Power--electricity, gasoline, diesel
2. Transportation--autos, airplanes, trucks, etc.
3. Communications--printing, electricity
4. Shelter--carpentry, drawing

"Civic Education" can be encouraged and practiced in an industrial arts program through the following methods:

1. Industrial arts club
2. Group projects for school or community
3. Organizational procedures and responsibilities typical of industrial applications: plant manager, foreman, designer, buyer, secretary-treasurer, etc. These titles would be assigned to
student personnel in keeping with their functions and responsibilities.

4. Displays throughout the community

5. Association with Boy Scouts

Probably one of the greatest contributions that industrial arts can offer, particularly to junior high school students, is in motivating these young people in the "Worthy Use of Leisure." People of all ages are interested and desire help in selecting or advancing in their hobbies. Industrial arts contributes to this objective through such subjects as:

1. Craft work--carving, leather, archery, fly tying
2. General metalwork--art metal, sheet metal, foundry, welding, machinery
3. General woodwork--furniture making, carpentry, boat making
4. General printing--book binding, type setting, press operation, type study
5. Plastics--machining, casting, forming
6. Lapidary and jewelry--collecting, cutting and polishing, silver work
7. Painting and finishing--woods, metals, plastics

"Ethical Character" in every student is most certainly encouraged in the school shop through such experiences as:
1. Honesty--figuring costs of materials; responsibility for tools, etc.
2. Truthfulness--stating what he can do
3. Dependability--in work assignments
4. Industry--careful planning and thoughtful work
5. Judgment--in use of machines and arrangement of work
6. Good business--in working relations with instructor and other students
7. Neatness--in upkeep of books, shop, and lockers

These and a great many other attributes can well be developed by a successful teacher. Poorly selected and insufficiently trained instructors who are not familiar with these objectives are in many ways detrimental to proper character building.

Every industrial arts teacher must have ideals toward which he guides his pupils. The ideals, or goals, may be chosen from the many that have been suggested by other educators and then tested in the proper situation, to determine if they produce desirable changes; or the shop teacher should be able to formulate his own objectives and test them. Whatever the source of the aims, the entire class must be aware of the objectives of the instruction given, and each individual should be made conscious of his advancement by means of tangible
evidence of his progress.

It might be well to examine a list of industrial arts teaching objectives suggested by Bawden and others (l:p.33) several years ago.

1. To develop in each pupil an active interest in industry and in industrial life, including the methods of production and distribution.

2. To develop in each pupil the ability to select wisely, care for, and use properly the things he buys or uses.

3. To develop in each pupil an appreciation of good workmanship and good design.

4. To develop in each pupil an attitude of pride or interest in his ability to do useful things.

5. To develop in each pupil a feeling of self-reliance and confidence in his ability to deal with people and to care for himself in an unusual or unfamiliar situation.

6. To develop in each pupil the habit of an orderly method of procedure in the performance of any task.

7. To develop in each pupil the habit of self-discipline which requires one to do a thing when it should be done, whether it is a pleasant task or not.

8. To develop in each pupil the habit of careful, thoughtful work without loitering or wasting time (industry).

9. To develop in each pupil an attitude of readiness to assist others when they need help and to join in group undertakings (cooperation).

10. To develop in each pupil a thoughtful attitude in the matter of making things easy and pleasant for others.
11. To develop in each pupil a knowledge and understanding of mechanical drawing, the interpretation of the conventions in drawings and working diagrams, and the ability to express ideas by means of drawing.

12. To develop in each pupil elementary skills in the use of the more common tools and machines in modifying and handling materials, and an understanding of some of the more common construction problems.

The background of the whole industrial arts program is general education, the function of which is to prepare individuals to fit correctly into the American scene with enjoyment and efficiency and for the good of mankind.

To return to welding instruction, the particular topic of this study, what desirable attitudes, habits, and accomplishments are students likely to acquire in a class in metalwork and welding, if the instructor selects carefully the experiences which are to accomplish these objectives of general education? In a successfully taught class in metalwork and welding, the students would have an opportunity to develop a good many traits and acquire considerable knowledge. The most noticeable developments would probably be as follows:

1. An understanding of the occupational and educational possibilities offered in the metalworking industries.

2. An appreciation of neat, orderly, and accurate workmanship in welding and metalwork. Also,
acquaintance with the welder and the importance of his work to modern industry.

3. The ability to estimate labor and commodity costs, or to buy and to use industrial metal products more intelligently.

4. The possible development of a leisure time activity in welding or related metalwork.

5. A knowledge of the source of ores, the manner of refining to metals, and the importance of metals to current economic life.

6. A perception of many social, economic, and industrial problems through a relationship between academic studies, real experiences in the school shop, and industrial visits or "field trips."

7. A feeling of satisfaction in being able to cut, form, and join metal into usable products of functional design.

8. The acquisition of a sufficient amount of skill and technical information applying to the fabrication of the common metals to keep his home and its equipment in repair, or for temporary employment in the event of such a need.
Definition of Terms

For purposes of this study a few terms are defined herewith, in accordance with their generally accepted usage in education.

**Industrial Arts** as a part of general education is concerned with satisfying the innate constructive tendencies of man through contacts with a wide variety of tools, materials, and processes of industry.

The late Professor of Education at Columbia University, Frederick Gordon Bonser, whose aim in industrial arts was to bring more meaning to life, stated (2:p. 105):

Industrial arts is thus a study that enlists all of the learning and active impulses and abilities of children—manipulative, investigative, aesthetic and social. It represents fields of real need in both child life and adult life. It uses the minds of children quite as much as their hands. It leads on to related fields of cultural content, giving a basis for an interest in and an appreciation for much of history, geography, science, literature, and art for which children and students otherwise would have no approach nor any adequate means of understanding.

Speaking of industrial arts as a subject in secondary education, Dr. Bonser continued (2:p. 93):

**Industrial Arts**, as a school subject, is the distilled experience of man in his resolution of natural materials to his needs, for creature comfort, to the end that he may more richly live his spiritual life. But this experience must ever be in due relationship to
the experience of the race of living this spiritual life itself or our true purpose is defeated.

Vocational education is specific occupational training in preparation for a specific trade or non-professional occupation. It is not considered as general education, but merely as trade training.

Bonser (2:p.71) again very eloquently compares industrial arts and vocational education:

It is offered that the general school system should provide as a part of its legitimate work those phases of the industrial arts which are primarily educational; and that whenever specialized training whose chief endpoint is a high degree of skill and technical efficiency becomes the primary aim, the work of the segregated trade or vocational school or course should begin. This attitude for both the elementary and the secondary schools in the general system would limit work in manipulation of materials and processes of construction actually participated in to those whose purpose is the development of clear ideas and appreciative insights.

Cox (3:p.5) clearly defined vocational education as

Any experience, educational or practical, which contributes directly to the specific skills or information required for vocational competency in a specific trade, occupation or pursuit. Vocational values can seldom be realized from any instruction except as that instruction is pointed specifically and intentionally toward application in a particular occupation or trade.

A unit shop is one whose total equipment and subject matter is selected and arranged for instruction in one type of manipulative work. Unit shops are usually named according to the processes performed, such as "welding
shop," "machine shop," or a "drafting room," each of which would specialize in the single type of work represented by the title.

Ericson (4:p.305) defines a unit shop and gives a comparison with the general shop:

The so-called "unit shop," which is a part of an organization containing many shops, is a well-known type. Strictly speaking, it is, of course, a one-activity shop.

... there are many who consider that whenever a school has sufficient enrollment to demand several shops and several shop teachers, separate shops for woodwork, electricity, metalwork, printing, and others, are preferable to the plan of combining some of each of these activities in each of several shops. This conviction is not unanimous, however, since some see an objectionable "no-man's land" not adequately covered by the organization of a series of unit shops, and for this reason they prefer combinations in one shop.

A composite general shop is a "general shop" consisting of several unrelated shop activities, such as printing, welding, woodwork, drawing, electricity, and art metal work. The primary objective for such a shop would be a broad exploratory program.

A related activities shop is a "general shop" which includes several closely connected shop activities, such as machine shop, foundry work, welding shop, and sheet metal work. The tools and equipment would, in many instances, be common to all areas, and the materials for all activities would be similar.
According to Cox (3:p.4), this type of shop often requires two instructors when classes are large and a wide variety of experiences are offered.

**General Shop** - A type of shop organization in which instruction is given in the informational and the manipulative content of several "experience areas." The number of such areas may vary from three to six or more, usually taught simultaneously and, in the small schools, all under the immediate supervision of one teacher. A few large schools conduct "general shops" with two or more teachers functioning simultaneously in one large room, instructing a larger number of students than could be handled by one teacher.

The general shop very definitely requires a versatile instructor with the proper personality, and a shop that is intelligently planned. The problem of instruction and individual attention can be simplified by dividing the class into small groups, and by using well-prepared instruction sheets and other teaching aids.

**Laboratory of Industries.** This type of shop incorporates areas representing several industries, such as metalwork, woodwork, printing, drawing, and others, all housed in one laboratory. The instructor is the administrator, and the students are employed as laborers, semiskilled and "skilled" technicians. The organization of student personnel is designed to aid in the supervision of instruction.

This form of instruction, designed by William E.
Warner, Ohio State University, employs many of Bonser's ideas. The plan was considered by Bawden and others (1: p.96) for adoption in the East, but has not been adopted in the West.

The term, "Laboratory of Industries," was selected because the whole situation is to represent modern industry. The laboratory is to be a center about which the study of industry revolves. Not only does this plan include a wide diversity of industries in its purview, but much stress is laid upon the development of a plan of organization which shall play a large part in the educational results to be attained. There will be a delegation of authority from the instructor to a considerable percentage of the class membership who will act in the capacity of superintendents, foremen, clerks, toolroom and stockroom attendants, and the like. The instructor will be an executive acting in an advisory capacity. There is a wide range of industries represented (automotive, ceramics, electricity, metal, printing, photography, woodwork, and others). A definite attempt is made to carry on an elaborate program of pupil participation. These factors indicate that the methods of instruction must be such as will grow out of a careful analysis of (1) the functions to be performed by the individual in each position of the personnel organization, (2) the qualities or traits essential to carry assigned responsibilities, followed by the development of instructional materials covering the actual tool uses and processes carried on in each of the different phases of industry represented in the laboratory.

A welding shop as considered in this study is a "related activities" metal shop in which a large portion of the work performed is cutting, forming, and joining metals into usable objects by means of heat from the oxyacetylene flame and electric arc. The form of education is
exploratory industrial arts, with many opportunities for shop lessons related to mathematics, economics, physics, and chemistry. Other experiences which might be included in this general shop are forging, ornamental iron work, and sheet metal construction.

**State Courses of Study**

Every state should publish and keep revised a course of study in industrial arts, and every teacher in the profession should be conscious of its standards. The formulating of such a document would require the cooperation of all the teachers in the profession, a thorough study of the needs and objectives of each phase of instruction, plus the interest and services of an active committee to formulate the report.

Represented in such a group should be several who are highly skilled in shop work and well experienced in teaching. There should be educators from junior and senior high schools, junior college, college, and adult training centers. The administrators present would be those with the most liberal points of view from the public schools, industrial education, and teacher-training institutions. The chairman of the group should be an administrator with several years of teaching experience in public schools and with complete knowledge of the state teachers colleges.
The logical person to instigate such a study would normally be the state director or supervisor of industrial arts, who could be appointed with the approval of the State Industrial Arts Association. However, there is no state director or supervisor in California, and the teachers have no representative in the state department of education. Therefore, courses of study are prepared for each shop, usually by the teacher. Often the outlines or plans are not recorded and students are given only a vague conception of the purpose of the instruction they receive. Instructors seldom offer similar courses, and in the training programs from junior high school to college there is constant repetition of fundamental tool operations without advancement.

Many state departments of education provide courses of study. The State Department of Education in Oregon, for example, accepted in 1937 the course of study formulated by a committee of interested teachers, under the chairmanship of George B. Cox, head of the Industrial Arts Department at Oregon State College. The committee performed an excellent service in gathering information for the study, in planning, and in assembling a booklet which was printed by the State Printing Department and issued to all schools. The value of this book is indicated by the following excerpt from its foreword (11:4):
The State Department of Education thanks the committee sincerely, not only on its own behalf and that of the many teachers who will find the course of study a splendid guide but also on behalf of the many young people who will find their schoolwork more vital, more interesting, and more meaningful because of an enriched industrial arts program.

Signed:

C. A. HOWARD
Superintendent of Public Instruction

Of course, pupils, student teachers, administrators, and teachers appreciated this valuable guide. It solved many problems too complex for one person, it presented organized outlines for instruction, and it aided in the planning, raising, and maintaining of school shops at reasonable specifications.

In considering what should be included in an industrial arts state course of study, it would be wise to examine the table of contents stated in Oregon's plan (ll. 5):

Division One: Problems of Organization and Instruction

I. Introduction
II. Types of Shop Organization
III. The Teacher
IV. Minimum Size of School Which May Support an Industrial Arts Program
V. Time Allotment
VI. Method of Instruction
VII. Use of Instruction Sheets
VIII. Sample Instruction Sheets
IX. Shop Planning and Organization
X. Space Required for Shop Purposes
Division Two: Units of Instruction

I. General Mechanical Drawing
   A. Introduction
   B. Units of Instruction in General Mechanical Drawing, Section I
   C. Units of Instruction in General Mechanical Drawing, Section II

II. General Woodworking
   A. Introduction
   B. Units of Instruction in General Woodworking, Section I
   C. Units of Instruction in General Woodworking, Section II

III. General Metal Working
   A. Introduction
   B. Units of Instruction in Flat Metal Working
   C. Units of Instruction in Cold Metal Working
   D. Units of Instruction in Hot Metal Working

IV. General Electricity
   A. Introduction
   B. Units of Instruction in General Electricity

V. General Crafts
   A. Introduction
   B. Units of Instruction in Metal Casting
   C. Units of Instruction in Concrete Work
   D. Units of Instruction in Leather Working

VI. General Power Mechanics
   A. Introduction
   B. Elementary Principles of Power
   C. The Wheel
   D. Harnessing Nature's Great Forces
   E. Steam Power
F. Internal Combustion Engines
G. The Gasoline Propelled Vehicle
H. Electric Power

Division Three: Equipment Lists and Suggestions for Installing Shop Equipment

I. Selection of Equipment
II. Classification of Equipment
III. Minimum Woodworking Equipment
IV. Minimum Mechanical Drawing Equipment
V. Summary of Equipment Costs
VI. Distributing the Budget Over a Three-Year Period
VII. Shop Built Equipment
VIII. Organization and Storage of Equipment
IX. Supplies

The states of Washington and Utah have formulated similar plans which have proved to be a satisfactory means of organizing, advancing, and enriching industrial arts education. It would seem advisable for every state to conduct this type of study and establish for publication its own standards of education.
CHAPTER III

A SURVEY OF SCHOOLS OFFERING WELDING

Introduction

This survey of California secondary schools offering welding was made in order to gather data on present conditions and to secure a cross-section of opinions of teachers in the field. In this manner, factual material was collected, scored, and summarized. The results were then interpreted for their indications on welding as a medium of instruction in the industrial arts program.

Questions were selected to give a true picture of the status of welding as a subject, either to be defended or condemned. A college class of future industrial arts teachers aided in the initial consideration of these questions. Inquiries were formulated so that either a ranking or a checking response was sufficient. Ample space was provided for comment, however, and many took advantage of it.

Two hundred questionnaires were mailed to welding teachers of all high schools with a student enrollment over 700; to all junior colleges listing industrial arts in their programs, and to a few public trade schools. Of the total number of questionnaires sent out, fifty percent were returned. The small percentage of replies was
probably due to the time of year (May 12, 1947), and to the fact that schools which did not employ instructors in metalworking subjects did not care to participate. A copy of the questionnaire may be found in the appendix.

For the first question, "Is welding taught in your schools?", the questionnaire was set up in two parts, only one of which was to be answered, depending on whether the reply to the first question was "yes" or "no." For purposes of better interpretation, returned questionnaires were divided into five groups: high schools with fewer than 1000 students, high schools with 1000 to 1500, high schools of over 1500, junior colleges, and trade schools. This division, in the case of the high schools, resulted in groups of about thirty each.

In order that comments on answers may be more easily understood, each question will be re-stated here, followed by tabulated answers and remarks.

**Analysis of Questionnaire**

**Question 1A.** "Is welding taught in your school?"

The majority of schools answered "yes." In many cases, welding is taught only as a part of a general shop program or of another course, rather than as a unit shop experience. Thus it may be one of the units in general metals, or simply a lesson taught individually to students
who need the knowledge to complete a project in auto shop or farm mechanics.

**TABLE I**

Comparison of the Number of Schools Teaching Welding with Those not Teaching Welding

<table>
<thead>
<tr>
<th>Is welding taught?</th>
<th>H. S. H. S.</th>
<th>H. S.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Under 1000</td>
<td>1500</td>
</tr>
<tr>
<td>Yes</td>
<td>26</td>
<td>21</td>
</tr>
<tr>
<td>No</td>
<td>4</td>
<td>6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Junior Colleges</th>
<th>Trade Schools</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>4</td>
<td>80</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>19</td>
</tr>
</tbody>
</table>

No percentages are given with these figures as total approximates 100.

Section B was to be answered only if welding was not offered. The analysis of questions in that section follows.

**Question 1B.** "Do you see a need for the teaching of welding?"

Opinion was very evenly divided on this question. One teacher who answered "yes," qualified his response by adding that the only need he saw for welding was in sheet metal work.
TABLE II

Comparison of Opinions of Instructors in Schools Where No Welding Is Taught

<table>
<thead>
<tr>
<th>Is welding needed?</th>
<th>H.S. under 1000</th>
<th>H.S. 1000-1500</th>
<th>H.S. over 1500</th>
<th>Junior Colleges</th>
<th>Trade Schools</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>1</td>
<td>.06</td>
<td>4</td>
<td>.24</td>
<td>3</td>
<td>.18</td>
</tr>
<tr>
<td>No</td>
<td>2</td>
<td>.11</td>
<td>2</td>
<td>.11</td>
<td>4</td>
<td>.24</td>
</tr>
</tbody>
</table>

Question 2B. "If you feel there is a need, please re-arrange the following reasons (general education, consumer education, avocational outlet, handy-man ability, pre-vocational value, opportunity to create, knowledge of industrial processes) in order of their importance."

Since there were only nine answers here, the responses were totaled with those given to the same question in section C, that part of the questionnaire to be answered by those who do offer welding.

Question 3B. "For what reasons is welding not offered at your school?"

Lack of space appears to be one of the most important factors prohibiting instruction in welding. Two schools
added that their shops had wooden floors and poor ventilation. The one junior college in which welding was not taught stated that its shops were still in the process of organization. One large city high school was purely college preparatory, and a trade school was said to meet the need there.

"No trained teacher" was checked by only four, but one instructor expressed the case so well that a letter he mailed with the questionnaire is quoted here:

Because of the widespread use of the welding process, it is imperative that all students be given information about welding. To my mind, its inclusion in a course of general metalworking is as important as units in filing, drilling, etc.

The main reason it is not taught in more schools is the lack of training that most industrial arts teachers get in most of our teacher-training institutions. I make this statement because of my own experience. I know that the courses I had in college did not adequately train me to properly conduct classes in general metalworking. To make up for this lack of experience I have spent many summers working in all types of industry and attending special schools.

Probably most instructors feel that they could teach welding, but as one teacher pointed out in an additional comment, many of them are simply "handy men," rather than experts.

Few named expense as a reason for the lack of welding instruction. One replied that where there is a need, nothing is too expensive. Another stated that the number
of courses in welding had been cut for lack of funds. One instructor felt very strongly that instead of doing a half-way job, many shops should be closed until equipment, building, and budget met a set standard.

### TABLE III

Reasons for Not Offering Welding

<table>
<thead>
<tr>
<th>Reasons</th>
<th>H.S. Under 1000</th>
<th>H.S. 1500</th>
<th>H.S. Over 1500</th>
<th>Junior Colleges</th>
<th>Trade Schools</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expense</td>
<td>0</td>
<td>3</td>
<td>.09</td>
<td>2</td>
<td>.06</td>
<td>5</td>
</tr>
<tr>
<td>Lack of space</td>
<td>2</td>
<td>.06</td>
<td>3</td>
<td>.09</td>
<td>5</td>
<td>.13</td>
</tr>
<tr>
<td>No need</td>
<td>2</td>
<td>.06</td>
<td>1</td>
<td>.03</td>
<td>2</td>
<td>.06</td>
</tr>
<tr>
<td>Too dangerous</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>.09</td>
<td>1</td>
<td>.03</td>
</tr>
<tr>
<td>No trained teacher</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>.06</td>
<td>2</td>
<td>.06</td>
</tr>
<tr>
<td>Administration not in favor</td>
<td>2</td>
<td>.06</td>
<td>1</td>
<td>.03</td>
<td>3</td>
<td>.09</td>
</tr>
</tbody>
</table>

34 100
Section C was to be answered only if welding was offered. The analysis of questions in that section follows.

Question 1C. "Is welding taught for vocational ends or for industrial arts objectives?"

Industrial arts objectives were the goal of most schools, and though no space was given on the form for the answer, "both," many wrote that in. Often it was explained that half of the day in the shop was devoted to industrial arts classes; the rest was given to vocational students. In one case vocational assistance was given to a few boys who had part-time jobs as metal workers.

**TABLE IV**

Comparison of Number of Schools Teaching for Industrial Arts Objectives with Those Working for Vocational Ends

| Reasons for Teaching Welding | H.S. for Under 1000 | H.S. for 1000-1500 | H.S. for Over 1500 | Junior Trade Colleges Schools Total |
|------------------------------|---------------------|-------------------|-------------------|-------------------------------------|----------------------------------|
| Vocational ends | 4 | .05 | 4 | .05 | 4 | .05 | 2 | .03 | 3 | .04 | 17 | .22 |
| Industrial arts objectives | 14 | .17 | 15 | .19 | 15 | .19 | 0 | 0 | 0 | 0 | 44 | .55 |
| Both | 7 | .09 | 2 | .03 | 5 | .06 | 3 | .04 | 1 | .01 | 18 | .23 |

Total 79 100
Question 2C. "If taught from the industrial arts point of view, please re-arrange in the order of their importance the following objectives. (General education, consumer education, avocation outlet, pre-vocational value, handy-man ability, opportunity to create, knowledge of industrial processes)."

Underscored numbers in the following table show which objective was named the most frequently by each instructor. Those with asterisks are the runners-up. The teachers arranged the objectives in descending order of importance as follows: general education, knowledge of industrial processes, pre-vocational value, handy-man ability or opportunity to create (the same number of teachers voted for each of these for fourth place), avocational outlet, consumer education, and opportunity to create (more teachers voted this objective for seventh place than voted for any of the others for that position). One teacher suggested that the objective of "exploration" should be included, and marked it fourth in importance.

It is interesting to note that very few agree on the order of importance of objectives for industrial arts. This is probably due to the fact that the state has not made its teachers aware of the objectives, nor has state supervision been provided for industrial arts.
### TABLE V

**Ranking of Industrial Arts Objectives by Number of Votes Received**

<table>
<thead>
<tr>
<th>Objectives</th>
<th>1st</th>
<th>2nd</th>
<th>3rd</th>
<th>4th</th>
<th>5th</th>
<th>6th</th>
<th>7th</th>
</tr>
</thead>
<tbody>
<tr>
<td>General education</td>
<td>23</td>
<td>7</td>
<td>4</td>
<td>11*</td>
<td>6</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>Consumer education</td>
<td>1</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>10*</td>
<td>16</td>
<td>11*</td>
</tr>
<tr>
<td>Avocational outlet</td>
<td>2</td>
<td>6</td>
<td>4</td>
<td>10</td>
<td>16</td>
<td>14*</td>
<td>5</td>
</tr>
<tr>
<td>Pre-vocational values</td>
<td>14</td>
<td>17*</td>
<td>20</td>
<td>3</td>
<td>5</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Handy-man ability</td>
<td>12</td>
<td>10</td>
<td>13</td>
<td>15</td>
<td>9</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Opportunity to create</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>15</td>
<td>9</td>
<td>7</td>
<td>14</td>
</tr>
<tr>
<td>Knowledge of industrial</td>
<td>15*</td>
<td>19</td>
<td>16*</td>
<td>3</td>
<td>4</td>
<td>6</td>
<td>3</td>
</tr>
</tbody>
</table>

Underlined figures indicate most votes received.
* Asterisks indicate second most votes received.

**Question 3C.** "Does your community particularly need young men trained in welding?"

It will be noted here that a need was felt for welders, particularly in the larger communities (possessing the larger schools). One person commented that although a quantity of welders was not needed, there was always a job for one skilled in the trade. Another said that there was plenty of opportunity in the area, though the town itself had openings for only a few. In another school, two boys in each shop class are trained in welding in order
to assist with maintenance in the city schools. This practice was said to produce more welders than the community needs.

This question was formulated to determine the uses for metalwork and not the number of jobs available. Industrial arts is not interested in preparing students for the vocational trades. However, any student may select industrial arts instruction as an excellent foundation for specific vocational training. Industrial arts is a basic education for all students. It is obvious that a good many industrial arts teachers consider community need as a matter of possible future employment for their students.

**TABLE VI**

Comparison of Number of Communities Needing Young Men Trained in Welding With Those Which Do Not

<table>
<thead>
<tr>
<th>Does community need men trained in welding?</th>
<th>H.S. Under 1000</th>
<th>H.S. 1000-1500</th>
<th>H.S. Over 1500</th>
<th>Junior Colleges</th>
<th>Schools</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>14 .20 .12 .16 .25 3 .04 4 .05 51 .70</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>9 .12 .6 .08 5 .07 2 .03 0 .00 22 .30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| | | | | | | | |
| | | | | | | | |

| | | | | | | | |
| | | | | | | | |
Question 40. "Is welding offered in a 'unit shop' or a 'general shop' course?"

Most schools are offering welding instruction in a general metal shop. More unit shops are to be found in the larger high schools. Often when "general shop" was checked, it was explained that this was a metal, auto, farm, machine, or aeronautics shop. One teacher was dissatisfied with welding as an area in the general shop "because it requires so much practice." Obviously time was a factor in the decision to include welding in the general shop course.

<table>
<thead>
<tr>
<th>How is welding offered?</th>
<th>H.S. Under 1000</th>
<th>H.S. 1000-1500</th>
<th>H.S. Over 1500</th>
<th>Junior Colleges</th>
<th>Trade Schools</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of Schools</td>
<td>Per Cent</td>
<td>No. of Schools</td>
<td>Per Cent</td>
<td>No. of Schools</td>
<td>Per Cent</td>
</tr>
<tr>
<td>Unit shop</td>
<td>2</td>
<td>.03</td>
<td>4</td>
<td>.05</td>
<td>7</td>
<td>.09</td>
</tr>
<tr>
<td>General shop</td>
<td>24</td>
<td>.29</td>
<td>17</td>
<td>.21</td>
<td>17</td>
<td>.21</td>
</tr>
<tr>
<td>Both</td>
<td>0</td>
<td>.00</td>
<td>0</td>
<td>.00</td>
<td>0</td>
<td>.00</td>
</tr>
</tbody>
</table>

80 100
Questions 5C and 6C. From question 5C, "Approximately how many students study welding during a school year?" and question 6C, "How many boys attend your school?", the percentage of boys taking welding was calculated.

**TABLE VIII**

Percentage of Boys Taking Welding in Schools Surveyed

<table>
<thead>
<tr>
<th>Percentage of boys taking welding</th>
<th>H.S.</th>
<th>H.S.</th>
<th>H.S.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Under 1000</td>
<td>1000-1500</td>
<td>Over 1500</td>
</tr>
<tr>
<td></td>
<td>Colleges</td>
<td>Schools</td>
<td>Total</td>
</tr>
<tr>
<td>No. of Schools</td>
<td>Per Cent</td>
<td>No. of Schools</td>
<td>Per Cent</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>----------</td>
<td>---------------</td>
<td>----------</td>
</tr>
<tr>
<td>0 - 5%</td>
<td>4</td>
<td>.05</td>
<td>5</td>
</tr>
<tr>
<td>6 - 10%</td>
<td>2</td>
<td>.03</td>
<td>7</td>
</tr>
<tr>
<td>11 - 15%</td>
<td>2</td>
<td>.03</td>
<td>2</td>
</tr>
<tr>
<td>16 - 20%</td>
<td>4</td>
<td>.05</td>
<td>1</td>
</tr>
<tr>
<td>21 - 30%</td>
<td>5</td>
<td>.04</td>
<td>3</td>
</tr>
<tr>
<td>31 - 40%</td>
<td>4</td>
<td>.05</td>
<td>2</td>
</tr>
<tr>
<td>41 - 50%</td>
<td>1</td>
<td>.01</td>
<td>0</td>
</tr>
<tr>
<td>51 - 60%</td>
<td>1</td>
<td>.01</td>
<td>0</td>
</tr>
</tbody>
</table>

Naturally, as the size of the school increased, percentage grew less, and more schools taught a small percentage of the students. The reason for the high percentage "taught" welding in the smaller schools is that
many in a general metals class, for example, would get vicarious experience only, though listed as students, studying welding. Schools in the "under 1000" group were likely to teach welding to a greater percentage of their students, as many were in the farming districts and listed classes in vocational agriculture or farm mechanics.

Question 7C. "Is the student demand for welding large or small?"

The number of schools which stated that the demand was small exceeded the number of those indicating a large call for this subject. However, from comparison of the amount of welding equipment listed and the number of students handled, it appears that in most schools the welding equipment found in the shops is used to some extent. No space was provided for the answer "medium," but a few so described their demand. It is quite probable that the teachers' statements are directly affected by the amount of equipment, the type of work accomplished, and the instructor's ability. Students want shop courses well organized to provide efficient instruction and to enable them to use modern equipment to solve their problems.
TABLE IX

Comparison of Student Demand for Welding

<table>
<thead>
<tr>
<th>Student demand for welding</th>
<th>H.S. Under 1000</th>
<th>H.S. 1500</th>
<th>H.S. 1500</th>
<th>Junior Colleges</th>
<th>Trade Schools</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Schools</td>
<td>Per Cent</td>
<td>Per Cent</td>
<td>Per Cent</td>
<td>Per Cent</td>
<td>Per Cent</td>
<td>Per Cent</td>
</tr>
<tr>
<td>Large</td>
<td>11 .15</td>
<td>8 .10</td>
<td>8 .10</td>
<td>3 .04</td>
<td>3 .04</td>
<td>33 .43</td>
</tr>
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<td>2 .03</td>
<td>0 .00</td>
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<tr>
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<td>1 .01</td>
<td>2 .03</td>
<td>0 .00</td>
<td>1 .01</td>
<td>5 .06</td>
</tr>
</tbody>
</table>

75 100

Question 8C. "What is the largest number of students you can handle in a welding class?"

Most schools teaching welding in a general shop were able to handle no more than five students, and at most under twenty. Only in one case were classes of twenty or more taught outside a unit shop. The amount of equipment, the floor space, and the type of instruction would have to be considered in measuring accurately the number of students efficiently taught.
### TABLE X
Average Enrollment in Welding Classes

<table>
<thead>
<tr>
<th>Average welding class enrollment</th>
<th>H.S. Under 1000</th>
<th>H.S. 1000-1500</th>
<th>H.S. Over 1500</th>
<th>Junior Colleges</th>
<th>Trade Schools</th>
<th>Total</th>
<th>Per Cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Schools</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Per Cent</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 or under</td>
<td>7</td>
<td>.11</td>
<td>4</td>
<td>.05</td>
<td>11</td>
<td>.15</td>
<td>0</td>
</tr>
<tr>
<td>6-10</td>
<td>6</td>
<td>.09</td>
<td>5</td>
<td>.07</td>
<td>4</td>
<td>.05</td>
<td>0</td>
</tr>
<tr>
<td>11-15</td>
<td>4</td>
<td>.05</td>
<td>5</td>
<td>.07</td>
<td>2</td>
<td>.03</td>
<td>2</td>
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<tr>
<td>16-20</td>
<td>3</td>
<td>.04</td>
<td>4</td>
<td>.05</td>
<td>3</td>
<td>.04</td>
<td>2</td>
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<td>21-25</td>
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<td>26-30</td>
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<td>0</td>
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<td>2</td>
<td>.03</td>
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</table>

| 73 100                            |                 |                 |                |                 |              |       |         |

**Question 9C.** "In what grade or grades may students enroll in welding courses?"

Welding is offered most often in the tenth, eleventh, and twelfth grades of high school. Fewer trade schools and junior colleges responded than did high schools, so that, although the numbers they reported are smaller, the percentage is higher. The grade level indicated by many as best suited for the beginning of this type of instruction is the sophomore year. The freshman year probably should be devoted to an introductory shop program, which
would give those interested in welding an opportunity to explore its possibilities.

TABLE XI
Grades in Which Students May Enroll in Welding Courses

(Percentage for high schools done separately from junior colleges and trade schools)

<table>
<thead>
<tr>
<th>Grades in</th>
<th>H.S. Col-</th>
<th>Junior</th>
<th>J.C. &amp; Tr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>which</td>
<td>under 1000</td>
<td>Over 1500</td>
<td>Tals</td>
</tr>
<tr>
<td>students</td>
<td>1000</td>
<td>1500</td>
<td></td>
</tr>
<tr>
<td>may enroll in welding classes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of Schools</td>
<td>No. of Schools</td>
<td>No. of Schools</td>
<td>No. of Schools</td>
</tr>
<tr>
<td>No. Per Cent</td>
<td>No. Per Cent</td>
<td>No. Per Cent</td>
<td>No. Per Cent</td>
</tr>
</tbody>
</table>

| 8th     | 3.02 | 0.00 | 0.00 | 3.02 | 0.00 | 0.00 |
| 9th     | 8.05 | 7.04 | 0.00 | 15.09 | 0.00 | 0.00 |
| 10th    | 17.10 | 16.10 | 11.06 | 44.26 | 0.00 | 1.04 | 1.04 |
| 11th    | 21.12 | 15.09 | 23.12 | 59.33 | 2.09 | 2.09 | 4.18 |
| 12th    | 18.10 | 14.08 | 23.12 | 55.30 | 2.09 | 2.09 | 4.18 |
| 13th    | 0.00 | 0.00 | 0.00 | 0.00 | 5.21 | 2.09 | 7.30 |
| 14th    | 0.00 | 0.00 | 0.00 | 0.00 | 5.21 | 2.09 | 7.30 |

| Total   | 176 | 100 | 23 | 100 |

Question 10C. "How much floor space is devoted to welding in your shop?"

The results of the survey on the number of square feet allotted to welding equipment and working space in the various schools reveal that the most common space
44

allotment is between 51 and 100 square feet, indicating that welding is ordinarily a part of a general shop plan. The relatively few unit shops reported have an average floor space of between 1000 and 4000 square feet. The possibility of error in these figures is great, due to the fact that the shop space reported by the instructor was often only an approximation. No statement was made by teachers on the number of square feet per pupil.

TABLE XII

Amount of Floor Space Devoted to Welding in Schools Surveyed

<table>
<thead>
<tr>
<th>Number of Schools</th>
<th>H.S. Under 1000</th>
<th>H.S. 1000-1500</th>
<th>H.S. 1500-2000</th>
<th>Junior Trade Colleges</th>
<th>Senior Trade Schools</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Schools</td>
<td>Per Cent</td>
<td>No. of Schools</td>
<td>Per Cent</td>
<td>No. of Schools</td>
<td>Per Cent</td>
<td>No. of Schools</td>
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<td>25 &amp; under</td>
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<td>0.00</td>
<td>0.09</td>
<td>0.00</td>
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</tr>
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<td>0.03</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
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<tr>
<td>201-300</td>
<td>0.01</td>
<td>0.03</td>
<td>0.03</td>
<td>0.01</td>
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<td>301-400</td>
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<td>0.01</td>
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<td>0.00</td>
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<td>0.00</td>
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</table>

75 100
Questions 11C and 12C. The questions, "How many electric welding outfits are you using?" and "How many gas welding outfits are you using?", showed that gas welding, being more versatile, is more popular than electric welding with both large and small schools.

**TABLE XIII**

Number of Electric Welding Outfits Used

<table>
<thead>
<tr>
<th>Number of outfits</th>
<th>H.S. Under 1000</th>
<th>H.S. 1500</th>
<th>H.S. Over 1500</th>
<th>Junior Colleges</th>
<th>Total</th>
<th>Schools</th>
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<td>No. of Schools</td>
<td>No. of Schools</td>
<td>No. of Schools</td>
<td>No. of Schools</td>
<td>No. of Schools</td>
</tr>
<tr>
<td></td>
<td>Per Cent</td>
<td>Per Cent</td>
<td>Per Cent</td>
<td>Per Cent</td>
<td>Per Cent</td>
<td>Per Cent</td>
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<td>0.01</td>
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<td>0.05</td>
<td>7</td>
<td>0.09</td>
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<td>0.10</td>
<td>4</td>
<td>0.05</td>
<td>6</td>
<td>0.08</td>
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<td>0.04</td>
<td>4</td>
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</tr>
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<td>0.00</td>
</tr>
<tr>
<td>21-25</td>
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<td>0.00</td>
<td>0</td>
<td>0.00</td>
<td>0</td>
<td>0.00</td>
</tr>
</tbody>
</table>

| Total             | 79             | 100        |
TABLE XIV

Number of Gas Welding Outfits Used

<table>
<thead>
<tr>
<th>No. of Outfits</th>
<th>H.S. Under 1000</th>
<th>H.S. 1000-1500</th>
<th>H.S. Over 1500</th>
<th>Junior Colleges</th>
<th>Trade Schools</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Schools</td>
<td>No. of Schools</td>
<td>No. of Schools</td>
<td>No. of Schools</td>
<td>No. of Schools</td>
<td>No. of Schools</td>
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</tr>
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<td>1.01</td>
<td>0.00</td>
<td>0.00</td>
<td>0.01</td>
</tr>
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<td>0.00</td>
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<td>3.04</td>
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<td>0.00</td>
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</tr>
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<td>0.00</td>
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</tr>
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<td>0.01</td>
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<td>0.03</td>
</tr>
<tr>
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<td>0.06</td>
</tr>
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<td>0.01</td>
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<td>0.00</td>
<td>0.00</td>
</tr>
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<td>31-35</td>
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<td>0.00</td>
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<td>0.01</td>
</tr>
</tbody>
</table>

79 100

Question 13C. "How much money is budgeted annually for welding instruction?"

The majority of instructors evidently work under no set budget for welding. It is most often taught as a part of a general shop course. In that case the welding cost alone is difficult to estimate. In many cases, welding
equipment is scattered about in two or three shops, and
maintenance is carried on in the separate shops.

TABLE XV

Amount of Money Budgeted Annually
for Welding Instruction

<table>
<thead>
<tr>
<th>Amount of money</th>
<th>H.S. Under 1000</th>
<th>H.S. 1000-1500</th>
<th>H.S. Over 1500</th>
<th>Junior Colleges</th>
<th>Trade Schools</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Schools</td>
<td>Per Cent</td>
<td>No. of Schools</td>
<td>Per Cent</td>
<td>No. of Schools</td>
<td>Per Cent</td>
<td>No. of Schools</td>
</tr>
<tr>
<td>$100 or under</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$101-200</td>
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<td>.08</td>
<td>6</td>
<td>.08</td>
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<td>.00</td>
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<td>2</td>
<td>.03</td>
<td>1</td>
<td>.01</td>
<td>0</td>
<td>.00</td>
</tr>
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<td>$301-400</td>
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<td>.03</td>
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<td>.00</td>
<td>2</td>
<td>.03</td>
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<td>.01</td>
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</tr>
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<td>.01</td>
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</tr>
</tbody>
</table>

Question 14C. "What projects do your welding classes
normally work on?"

Virtually all schools offer an opportunity for each
student to work on individual problems or make repairs on
his family's home appliances or farm equipment. Several
schools indicate time spent on automotive repairs, such
as body and fender work. This, of course, is valuable instruction when well organized, and dangerous when the quality of work is not good. To reduce the number of student auto accidents, students should know and be able to do acceptable work. Repairs or remodeling of equipment performed in any school shop should meet definite standards or not be permitted in the shop.

The following list includes the various types of work performed in welding or general metal shops and the number of schools utilizing each type of experience.

**TABLE XVI**

A Survey of Welding Projects

<table>
<thead>
<tr>
<th>Type of Work</th>
<th>Number of Schools Utilizing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual projects</td>
<td>58</td>
</tr>
<tr>
<td>Practice samples</td>
<td>38</td>
</tr>
<tr>
<td>Farm repairs</td>
<td>31</td>
</tr>
<tr>
<td>Automotive repairs</td>
<td>29</td>
</tr>
<tr>
<td>Home repairs</td>
<td>14</td>
</tr>
<tr>
<td>School maintenance</td>
<td>12</td>
</tr>
<tr>
<td>School construction</td>
<td>4</td>
</tr>
<tr>
<td>Fabrication for machine shop</td>
<td>2</td>
</tr>
<tr>
<td>Work for community</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>(Charged for)</td>
</tr>
</tbody>
</table>

Probably all schools require practice samples, although they did not always list them. Certainly a student should not be permitted to weld a car frame or piece of farm machinery until he has demonstrated that he could do the job satisfactorily. It would be good practice for a beginning student to have another more experienced classmate perform or assist with the work. In the trade schools, much emphasis is put on the practice on samples.
In one junior college, the instructor described a project which he said stimulated more interest and effort than any other teaching device he had ever stumbled upon. A father of one of the students underwrote the construction of a scraper, and the teacher, a combination bale and sack loader. When the implements were finished, the class sold them for $600.00. Division of profit was made to suit the students' own analysis of work done by each person. After bills were paid, returns varied from $28.00 to $58.00 per student.

A welding class in a high school in a large city did a great deal of school maintenance during the war. According to the instructor, they kept both the school and other industrial arts classes going, by means of their repair work when new materials could not be procured.

Question 15C. "Do students have an opportunity to do the welding in constructing projects of their own?"

All schools reported that students were allowed to do the welding on their own projects. This is excellent motivation and should be encouraged, but not permitted to interfere with required projects, test samples, and the passing of examinations prior to undertaking any major problem.
### TABLE XVII

Comparison of Number of Schools Allowing Students to do the Welding on Individual Projects with Those Who Do Not

<table>
<thead>
<tr>
<th>Do students do welding on own projects?</th>
<th>H.S. Under 1000</th>
<th>H.S. 1500</th>
<th>H.S. Over 1500</th>
<th>Junior Colleges</th>
<th>Schools</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>20</td>
<td>.32</td>
<td>17</td>
<td>.27</td>
<td>21</td>
<td>.33</td>
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<tr>
<td>No</td>
<td>0</td>
<td>.00</td>
<td>0</td>
<td>.00</td>
<td>0</td>
<td>.00</td>
</tr>
</tbody>
</table>

It is surprising to note that every school surveyed permitted its students to perform the welding on their own projects. If such is the case, it is excellent pedagogy. However, the author questions the reliability of the returns on this inquiry. Perhaps the wording of the question led those surveyed to fail to understand that the statement was intended to reveal the number of schools permitting students to do the welding on their own projects.
CHAPTER IV

IDEAS OF ADMINISTRATORS AND EDUCATORS
ON THE FUTURE OF WELDING IN INDUSTRIAL ARTS

Opinions of California Supervisors

The questionnaires to supervisors of some of California's larger districts, in which most high schools offer industrial arts subjects and a few include welding, brought usable returns from 50 per cent of the sixteen supervisors contacted. Inquiries were designed to discover the percentage of schools offering welding, the ability of industrial arts instructors to teach welding, and the opinions of these administrators on the subject of welding instruction in the secondary schools. The first portion of the questionnaire was objective; the second, subjective. Questions and answers of the objective portion follow:

Question 1. "How many schools are there in your district? How many offer some instruction in welding?

From these two figures, a percentage was calculated. All school systems offered some welding and most systems taught welding in all high schools of the system. Since only 50 per cent of the sixteen supervisors responded, the results are only an approximation. The percentage of schools teaching welding as shown by this limited survey
would probably be greater than that shown by a more extensive survey.

**TABLE XVIII**

Percentage of Individual Schools Offering Welding in Districts Surveyed

<table>
<thead>
<tr>
<th>Number of California School Districts</th>
<th>Percentage of Schools that Offer Welding in the District</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>40%</td>
</tr>
<tr>
<td>1</td>
<td>58%</td>
</tr>
<tr>
<td>1</td>
<td>67%</td>
</tr>
<tr>
<td>1</td>
<td>75%</td>
</tr>
<tr>
<td>1</td>
<td>83%</td>
</tr>
<tr>
<td>3</td>
<td>100%</td>
</tr>
</tbody>
</table>

**Question 2.** From the question, "How many schools in your school district have welding equipment?", it was determined that more schools owned gas and electric welding outfits than gave welding as a school subject. The extra equipment may have been used for school maintenance; or its present inactive status may be due to inadequately trained teachers or the lack of welding instructors as an aftermath of war-born shortages.
TABLE XIX

Percentage of Schools Owning Welding Equipment in Districts Surveyed

<table>
<thead>
<tr>
<th>Number of California School Districts</th>
<th>Percentage of Schools that Have Welding Equipment in the District</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>58%</td>
</tr>
<tr>
<td>1</td>
<td>67%</td>
</tr>
<tr>
<td>1</td>
<td>75%</td>
</tr>
<tr>
<td>5</td>
<td>100%</td>
</tr>
</tbody>
</table>

Question 3. To the question, "How many schools employ instructors capable of teaching welding?", the supervisors of schools teaching welding responded that they felt their teachers capable. One limited his statement by saying that only one out of the seven could teach a vocational course. Although the results obtained are no more reliable than the judgment of the supervisor questioned, the purpose of the inquiry was to determine generally what per cent of the schools had industrial arts instructors who could teach welding. Probably, some schools do not offer this experience because they have no instructor skilled in welding. A very interesting letter on this matter is cited on page 59.
TABLE XX

Percentage of Instructors Judged Capable of Teaching Welding in Districts Surveyed

<table>
<thead>
<tr>
<th>Number of California School Districts</th>
<th>Percentage of Instructors in Districts Surveyed, Judged Capable of Teaching Welding</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>33%</td>
</tr>
<tr>
<td>1</td>
<td>40%</td>
</tr>
<tr>
<td>1</td>
<td>58%</td>
</tr>
<tr>
<td>1</td>
<td>75%</td>
</tr>
<tr>
<td>4</td>
<td>100%</td>
</tr>
</tbody>
</table>

Question 4. "Do you believe that welding should be offered only in vocational schools?" All answers to this question were negative.

Question 5. "Do you believe that welding should be offered in the industrial arts shops of all of our secondary schools?" Each supervisor answered "yes" to this inquiry.

Question 6. "What is your opinion (pro or con) of offering some form of welding instruction in the industrial arts program of most large secondary schools?"

Almost every one of the supervisors replying emphasized the need for welding instruction in public schools. Said Mr. Joseph White of the Ventura County Schools, "Welding has become a part of so many occupations and operations that it seems apparent to us that it could well be taught in the large secondary schools." Yvonne
Whitehurst, Supervisor of Arts and Crafts of Alameda County, declared, "Due to the modern trends in production, where so many products that were formerly made of wood are now constructed of some form of metal, it is necessary that we should give the avocational as well as the vocational student an opportunity to experience the processes of different forms of welding." The Kern County supervisor, Ray Messenger, stated, "I believe welding should be offered in all shops, as welding equipment is now available for the use of laymen as well as tradesmen."

Most supervisors questioned the advisability of a unit shop in welding, as a part of the industrial arts program, but William Steinberg, supervisor for the San Diego City School System, believes that "welding should be an important part of the General Metal program. We are not justified in teaching welding as a subject, but as a short part of a metal program. Every boy should have an opportunity to do elementary welding." Will C. Mathews of the Oakland Public Schools agrees with the foregoing opinion:

Only under unusual circumstances would I recommend welding as a unit course in the industrial arts program. I believe we should offer limited training in Senior, but not Junior, High School metal and auto shops, where both or either electric or acetylene welding is a tool—a convenient tool—. In each shop, auto
or metal, there should be training in the safe use of welding equipment for the limited kind of welding needed in auto repairs or simple metal fabrication, rather than an attempt at a full or all-round welding course. But, I repeat, every metal shop and auto shop teacher must have welding in this day and age...both electric and acetylene.

Mr. Mathews points to the fact that a technical high school in his city provides training for those vocationally interested in welding. He believes, too, that an industrial arts teacher should, above all, know and teach the safety features of welding.

Opinions of Educators

Several letters were sent to the heads of industrial arts departments of all California state colleges and to many other colleges throughout the United States, as a means of determining the general point of view of a group experienced in teacher education and supervision. Quotations which express the ideas of these men have been included in this chapter for evaluation and as an aid in presenting conclusions. The letters of inquiry used to gather this information are included in the appendix.

Samuel L. Fick, Chief, Bureau of Trade and Industrial Education, State Department of Education at Sacramento, offered no opinion in regard to welding instruction but suggested that the directors of industrial education at the various state colleges of California be
questioned. Mr. Fick did reply to a request for a state course of study in industrial arts by saying, "It has not been the policy of the State Department of Education to develop such a state course of study, and we are therefore unable to comply with your request."

E. E. Ericson, chairman of the Department of Industrial Arts at the University of California's Santa Barbara College, one of the state teacher education centers, replied:

In general, my feeling is that for industrial arts, welding can well be coordinated with other metal working subjects in a generalized, related activities type of metal shop. . . . Probably about forty per cent of our graduates in Santa Barbara take one course in welding and then have an opportunity to apply it in other areas of instruction in their teacher-training period. . . . At Santa Barbara we offer one 2-unit course in welding as a minimum for the so-called general metal shop credential. There is also an advanced course available in welding for men who wish to attain further skill and technical knowledge in that field.

The subjects listed in the Santa Barbara College catalog for 1946-47 are: Forging and Welding, 2 or 3 units; Advanced Welding, 2 or 3 units; and Aircraft Welding, 2 or 3 units.

Mr. M. A. Grosse, head of the industrial arts department and director of teacher education at Fresno State College, declared, "Welding instruction in the secondary schools of California is not what it should be," and, "Graduate teachers from the state colleges are
thoroughly skilled in welding and informed of its value to modern industry and civilization." The welding courses now offered in the newly developed program at Fresno are "Forging and Welding" for 1 to 4 units, and an upper division course in "Arc and Oxyacetylene Welding" for 1 to 4 units.

Dr. H. A. Sotzin, director of the industrial arts teacher education at San Jose State College, responded:

I do not believe welding should be offered as a unit shop in the industrial arts program. . . . The welding torch has become a tool of almost universal use and in the metal industry is almost as common as an arm or leg. In my opinion, it is an incidental tool and equipment which is used in many occupational fields and areas. I believe it has a place in general metals, in ornamental iron work, in machine shop, and in auto mechanics.

The courses offered at San Jose State which include welding instruction are: General Metal Survey, 5 units; Forging and Welding, 3 units; Ornamental Iron Work, 3 units; and Advanced Welding and Tool Making, 3 units.

Chico State College did not reply to the letter sent, so no statement can be made as to the policy of that institution. However, the school catalog lists two courses: Welding, 1 or 2 units, and Ornamental Iron and Welding, 3 units. Nothing can be said as to whether or not this work is stressed as a part of the training program.
All the institutions in the state of California that prepare industrial arts teachers for secondary school positions have been considered, and the courses they offer in welding have been listed. It has been found that all of the state colleges offer this experience both in unit shops and in general shops, and at least one course is required for a "general metal recommendation" on the special secondary teaching credential for California secondary schools.

Virtually all industrial arts teachers in California are employed on a "special secondary credential," which certifies that the holder is qualified to teach only industrial arts subjects. The teacher may be legally hired to teach any shop subject, but he is recommended as an instructor of the courses listed in the credential by his teacher-training institution. To obtain a recommendation to teach a unit shop course in welding, students would be required to earn approximately 15 quarter units and to acquire a reasonable amount of trade experience. Certainly it is to be expected that any high school instructor of general metals or welding must be thoroughly familiar with the industrial aspects, the metalworking techniques, the methods of teaching, and all the skills entailed in the welding processes.

Reflecting the opinions of supervisors from other
states, Gordon O. Wilbur, Director of the Division of Industrial Arts Teacher Education at State Teachers College, Oswego, New York, has been very helpful in offering suggestions to meet problems of the eastern states. Similar situations doubtless exist in the western states as well. Mr. Wilbur's letter is well worth including as a whole, since it is quite informative and has definite bearing on the purpose of this study.

Comparatively few schools have welding equipment or attempt to teach welding as a part of their industrial arts program. I should judge that not over 5 per cent of the schools that have industrial arts programs include welding as a part of their shop program.

Many schools that have welding equipment use it only on rare occasions and in many cases it is handled only by the teacher.

I should judge that the reason that welding is not more popular in the industrial arts program relates to the fact that it is of relatively recent development and also to the fact that many people feel that it is highly dangerous.

I believe that interest in welding as a part of the industrial arts program could be stimulated by giving extension and summer session courses in this area for industrial arts teachers. Probably one of the reasons why it is not more frequently found in our shops is that the instructors themselves do not know how to handle and use the equipment.

Dr. O. A. Hankammer, Head of Industrial and Vocational Education at Kansas State Teachers College, has contributed very generously to this study with such statements as the following:
I am personally in favor of welding on the upper levels in the high school industrial arts shops. It probably should have both electricity and gas. I should, however, be particularly concerned that you have a well-trained industrial arts teacher. . . . In-so-far as welding itself is concerned, there is no reason why it should not be included in an industrial arts program. It is one of the newer and certainly one of the growing processes in the field of fabrication. The subject of welding can be tied in quite intimately with metalurgy, chemistry, physics, drafting, and other related areas, hence, it should be rich in its contribution to a good industrial arts program.

The Dean of Industrial Education at the Stout Institute, Menomonie, Wisconsin, Mr. Clyde A. Bowman, has described briefly a welding program that is being offered with favorable results in the secondary schools of Wisconsin.

Here at Stout in the training school we give acetylene welding and cutting to tenth grade high school students in the general metal course as one unit of work for a duration of eighteen weeks, one and one-half hours per day, five days a week. Each student gets about thirty hours of work in the welding field. . . . There are many high schools in this state giving either or both electric and oxyacetylene from the ninth grade through the twelfth, with very satisfactory results.

Dr. William E. Warner, Head of Teacher Training and Graduate School of Industrial Education at Ohio State University, replied in a personal interview to the question, "Should welding instruction be offered in secondary schools?" by saying, "Welding most definitely should be included in the secondary school program when any study of metalwork is being conducted. The process itself is
not a basis for an exploratory program without related manipulative work and group projects in the study of the production of power, the processing of foods, construction, and transportation." In a recent letter Dr. Warner wrote:

In my scheme of things, the matter of welding is simply an essential phase of manufacture which should be included in the Industrial Arts experience of any normal adolescent boy and even girl. The matter of how much skill is a relative consideration.

A. H. Luehring, Associate Professor of Industrial Arts at Indiana State Teachers College, Terre Haute, Indiana, wrote that he had taught welding in college only, but commented that from former students who were teaching it in high school and from the college training school, he judged the situation as follows:

Welding is, in my opinion, a vital and necessary Industrial Arts area because it is a growing industry. It is a fascinating area for young people and one in which they are all more or less interested.

Most welding courses-of-study today are based upon the old exercise idea. It seems to me we need to develop good usable projects that will encompass within them the operations we wish to teach, and yet not require too much repetition. A short time must be devoted at the beginning of the term to exercises, but just as soon as possible we should begin to make things.

Mr. K. L. McFarland, Chairman of Industrial Arts at West Virginia Institute of Technology, is well
qualified to give an opinion on the value of welding.

During the war years he was in charge of the largest welding set-up in the world, at the Navy training center in Norman, Oklahoma. He declares:

When you speak of welding in high school industrial arts shops, I take it to mean the general shops or the laboratory of arts and industries. I believe gas welding should be the first welding equipment to include in the general shops. Arc welding would come next, since usually it is limited to the older students who might desire to specialize in welding.
CHAPTER V

COST OF SHOP INSTALLATION

The suggested type of high school shop described in this chapter is designed for a full program of instruction for about twenty students in general metalwork, to include instruction in the use of the electric arc and oxyacetylene flame as "tools" used in cutting, forming, and joining a wide variety of metals.

The general metal shop has been selected as the typical medium of instruction because of its popularity as evidenced in the responses of industrial arts educators and administrators contacted in the survey. Most believed that instruction in welding should be limited in high school to an experience area in a general metal shop. The type and size of "laboratory" or shop would, of course, be determined by the school attendance, the type of community, and the instructor's ability. The cost should not be a discouraging factor, if students are to receive proper instruction.

According to Cox (3:p.104) the space for such a general metal shop should be approximately "65 to 85 square feet of floor area per pupil." The floor may be of wood for those areas used for cold metalwork, but for hot metalworking processes it should be of concrete.
Steel-sash windows and concrete or masonry walls will decrease danger of fire. While the danger of fire is not grave, for greatest safety the entire shop should be fitted with overhead sprinklers, with auxiliary fire extinguishers in danger areas. The lighting, natural and artificial, according to Luckiesh (7:p.94-96), should produce 25 to 50 foot candles by night as well as day. There should be ample provision for windows and a forced draft system for best ventilation.

Approximate prices on welding equipment and supplies are listed in this chapter as a means of comparing the cost of installation, annual cost of supplies, and replacement or maintenance expense with other types of shops. Of course, there are methods of reducing the expense by leasing equipment, reducing amounts ordered, buying cheaper products, or buying all equipment on competitive bids.

It is not recommended that cheap products be purchased. Cheap articles do not always offer complete safety features, are not used in the better industrial shops, the manufacturer is not willing to check or service them in the field, and the small manufacturers do not offer instructional drawings, or films, or comparable teaching aids to accompany their products.

It is difficult to state accurately how long
equipment can be safely and efficiently used in a school shop before it is necessary to replace or rebuild its worn parts. This matter is dependent upon how well the instructor trains the students to perform operations correctly and to care for and appreciate the use of school property. Estimates on replacement of tools are based on the assumption of efficient instruction, correct usage at all times, and constant supervision by a competent instructor.
Oxyacetylene Welding Equipment

**TABLE XXI**
Suggested Oxyacetylene Welding Equipment and Supplies for a 20-Student High School General Metal Class

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Item</th>
<th>No.</th>
<th>Size</th>
<th>Manufacturer or Brand</th>
<th>Equipment Cost</th>
<th>Supplies Cost</th>
<th>Replacement yrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Torches</td>
<td>315</td>
<td></td>
<td>Victor</td>
<td>65.00</td>
<td></td>
<td>25</td>
</tr>
<tr>
<td>5</td>
<td>Nozzles</td>
<td>300E</td>
<td></td>
<td>&quot;</td>
<td>22.00</td>
<td></td>
<td>25</td>
</tr>
<tr>
<td>5</td>
<td>Tips #0</td>
<td>300E</td>
<td></td>
<td>&quot;</td>
<td>5.00</td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>Tips #1</td>
<td>300E</td>
<td></td>
<td>&quot;</td>
<td>5.00</td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>Tips #2</td>
<td>300E</td>
<td></td>
<td>&quot;</td>
<td>5.00</td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>Tips #3</td>
<td>300E</td>
<td></td>
<td>&quot;</td>
<td>5.00</td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>Tips #4</td>
<td>300E</td>
<td></td>
<td>&quot;</td>
<td>5.00</td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>Tips #6</td>
<td>300E</td>
<td></td>
<td>&quot;</td>
<td>2.00</td>
<td></td>
<td>10</td>
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<tr>
<td>5</td>
<td>Cutting Attachments</td>
<td>500-300</td>
<td>&quot;</td>
<td>82.50</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Cutting Tips #0</td>
<td>500A</td>
<td></td>
<td>&quot;</td>
<td>12.50</td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>Cutting Tips #1</td>
<td>500D</td>
<td></td>
<td>&quot;</td>
<td>12.50</td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>Cutting Tips #2</td>
<td>500D</td>
<td></td>
<td>&quot;</td>
<td>12.50</td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>Quantity</td>
<td>Item</td>
<td>No.</td>
<td>Size</td>
<td>Manufacturer or Brand</td>
<td>Equipment</td>
<td>Supplies</td>
<td>Replacement</td>
</tr>
<tr>
<td>----------</td>
<td>-----------------------------</td>
<td>-----</td>
<td>-------</td>
<td>-----------------------</td>
<td>-----------</td>
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<td>-------------</td>
</tr>
<tr>
<td>5</td>
<td>Lengths</td>
<td>1/4D</td>
<td></td>
<td>Victor</td>
<td>25.00</td>
<td></td>
<td>5 yrs</td>
</tr>
<tr>
<td></td>
<td>Hose (oxygen &amp; acetylene)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Oxygen Regulators</td>
<td>SR-50</td>
<td></td>
<td>&quot;</td>
<td>110.00</td>
<td>Check</td>
<td>1 yr</td>
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<tr>
<td>5</td>
<td>Acetylene Regulators</td>
<td>SR-60</td>
<td></td>
<td>&quot;</td>
<td>95.00</td>
<td>&quot;</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Eye Shields</td>
<td>Type A</td>
<td></td>
<td>Jackson</td>
<td>15.25</td>
<td>Glass</td>
<td>10 yrs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.70</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Tripl-Flint</td>
<td>3</td>
<td></td>
<td>Victor</td>
<td>2.50</td>
<td>Flint</td>
<td>5 yrs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>1 lb. cans</td>
<td>2</td>
<td></td>
<td>&quot;</td>
<td>4.25</td>
<td></td>
<td>2 yrs</td>
</tr>
<tr>
<td></td>
<td>Brazing flux for brasses &amp; copper</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>1 lb. cans</td>
<td>30</td>
<td></td>
<td>&quot;</td>
<td>4.25</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Brazing flux for cast iron</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>1 lb. Cans</td>
<td>Better</td>
<td></td>
<td>cast iron weld</td>
<td>3.75</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Handy flux</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>1 lb. jars</td>
<td>33</td>
<td></td>
<td>ALCOA</td>
<td>4.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Aluminum Brazing flux</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quantity</td>
<td>Item</td>
<td>No.</td>
<td>Size</td>
<td>Manufacturer or Brand</td>
<td>Equipment</td>
<td>Supplies</td>
<td>Replacement</td>
</tr>
<tr>
<td>----------</td>
<td>-----------------------------</td>
<td>-----</td>
<td>--------</td>
<td>------------------------</td>
<td>-----------</td>
<td>----------</td>
<td>-------------</td>
</tr>
<tr>
<td>5</td>
<td>1/2 lb cans Cast Alum. Flux</td>
<td>1</td>
<td></td>
<td>Victor</td>
<td></td>
<td>3.50</td>
<td>2 yrs.</td>
</tr>
<tr>
<td>5</td>
<td>1/2 lb cans Sheet Al. Flux</td>
<td>2</td>
<td></td>
<td>&quot;</td>
<td></td>
<td>3.50</td>
<td>&quot;</td>
</tr>
<tr>
<td>25#</td>
<td>Bronze Brazing Rods</td>
<td>10</td>
<td>1/16</td>
<td>&quot;</td>
<td></td>
<td>12.50</td>
<td>Annual</td>
</tr>
<tr>
<td>25#</td>
<td>Bronze Brazing Rods</td>
<td>10</td>
<td>1/8</td>
<td>&quot;</td>
<td></td>
<td>10.50</td>
<td>&quot;</td>
</tr>
<tr>
<td>50#</td>
<td>Steel Rods</td>
<td>4</td>
<td>1/16</td>
<td>&quot;</td>
<td></td>
<td>5.00</td>
<td>&quot;</td>
</tr>
<tr>
<td>50#</td>
<td>Steel Rods</td>
<td>4</td>
<td>3/32</td>
<td>&quot;</td>
<td></td>
<td>4.00</td>
<td>&quot;</td>
</tr>
<tr>
<td>50#</td>
<td>Steel Rods</td>
<td>4</td>
<td>1/8</td>
<td>&quot;</td>
<td></td>
<td>4.00</td>
<td>&quot;</td>
</tr>
<tr>
<td>50#</td>
<td>Steel Rods</td>
<td>4</td>
<td>5/32</td>
<td>&quot;</td>
<td></td>
<td>4.00</td>
<td>&quot;</td>
</tr>
<tr>
<td>10#</td>
<td>Moly-nickel cast iron rod</td>
<td>6A</td>
<td>1/4</td>
<td>&quot;</td>
<td></td>
<td>2.00</td>
<td>&quot;</td>
</tr>
<tr>
<td>25#</td>
<td>Cast iron rods</td>
<td>6</td>
<td>3/16</td>
<td>&quot;</td>
<td></td>
<td>4.00</td>
<td>&quot;</td>
</tr>
<tr>
<td>25#</td>
<td>Cast iron rods</td>
<td>6</td>
<td>1/4</td>
<td>&quot;</td>
<td></td>
<td>3.50</td>
<td>&quot;</td>
</tr>
<tr>
<td>5#</td>
<td>Drawn Al. rods</td>
<td>8</td>
<td>1/8</td>
<td>&quot;</td>
<td></td>
<td>3.00</td>
<td>&quot;</td>
</tr>
<tr>
<td>5#</td>
<td>Cast Al. rods</td>
<td>9</td>
<td>3/16</td>
<td>&quot;</td>
<td></td>
<td>4.30</td>
<td>&quot;</td>
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Table XXI (Continued)

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<tr>
<th>Quantity</th>
<th>Item</th>
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<th>Size</th>
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<th>Equipment</th>
<th>Supplies</th>
<th>Replacement</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 oz</td>
<td>Easy-flow rod</td>
<td>24</td>
<td>1/16</td>
<td>Victor</td>
<td></td>
<td>4.50</td>
<td>Annual</td>
</tr>
<tr>
<td>2#</td>
<td>Silfos-Rod</td>
<td></td>
<td>1/16</td>
<td>&quot;</td>
<td></td>
<td>6.60</td>
<td>&quot;</td>
</tr>
<tr>
<td>3#</td>
<td>Al. Brazing wire</td>
<td>716</td>
<td>1/16</td>
<td>ALCOA</td>
<td></td>
<td>2.25</td>
<td>&quot;</td>
</tr>
<tr>
<td>10#</td>
<td>Eutectic rod (steel)</td>
<td>16</td>
<td></td>
<td>Eutectic</td>
<td></td>
<td>4.00</td>
<td>&quot;</td>
</tr>
<tr>
<td>1</td>
<td>Eutectic jar flux</td>
<td>16</td>
<td></td>
<td>&quot;</td>
<td></td>
<td>.90</td>
<td>&quot;</td>
</tr>
<tr>
<td>10#</td>
<td>Eutectic rod (copper color)</td>
<td>183</td>
<td></td>
<td>Eutectic</td>
<td></td>
<td>4.00</td>
<td>&quot;</td>
</tr>
<tr>
<td>1</td>
<td>Eutectic jar Flux</td>
<td>183</td>
<td></td>
<td>&quot;</td>
<td></td>
<td>.90</td>
<td>&quot;</td>
</tr>
<tr>
<td>2#</td>
<td>Eutectic Rod-Die casting</td>
<td>95</td>
<td></td>
<td>&quot;</td>
<td></td>
<td>1.00</td>
<td>&quot;</td>
</tr>
<tr>
<td>1</td>
<td>Eutectic jar Flux</td>
<td>95</td>
<td></td>
<td>&quot;</td>
<td></td>
<td>.90</td>
<td>&quot;</td>
</tr>
<tr>
<td>8 oz</td>
<td>Silver solder sheet</td>
<td></td>
<td>.005</td>
<td>Dixon</td>
<td></td>
<td>2.50</td>
<td>&quot;</td>
</tr>
<tr>
<td>6</td>
<td>Welding benches</td>
<td></td>
<td></td>
<td>Instructor 50.00 and students</td>
<td></td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Quantity</td>
<td>Item</td>
<td>No.</td>
<td>Size</td>
<td>Manufacturer or Brand</td>
<td>Cost</td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------</td>
<td>---------------------</td>
<td>-----</td>
<td>------</td>
<td>-----------------------</td>
<td>------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Cylinder trucks</td>
<td></td>
<td></td>
<td>Instructor and students</td>
<td>10.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Preheating bench</td>
<td></td>
<td></td>
<td>&quot;</td>
<td>10.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Preheating torches</td>
<td></td>
<td></td>
<td>&quot;</td>
<td>5.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Positioning bench</td>
<td></td>
<td></td>
<td>&quot;</td>
<td>7.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Metal rack</td>
<td></td>
<td></td>
<td>&quot;</td>
<td>10.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Supply cabinet</td>
<td></td>
<td></td>
<td>&quot;</td>
<td>15.00</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

TOTAL: 589.25 116.30
### Electric Welding Equipment

**TABLE XXII**

Suggested Arc Welding Equipment and Supplies for a 20-Student High School General Metal Class

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Item</th>
<th>No.</th>
<th>Size</th>
<th>Manufacturer or Brand</th>
<th>Equipment</th>
<th>Supplies</th>
<th>Replacement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>D.C. Motor Driven, Dual Control, Elec. Welder (Portable)</td>
<td>300</td>
<td>Lincoln Amp</td>
<td>455.00</td>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>A.C. Transformer Electric Welder</td>
<td>200</td>
<td>&quot;</td>
<td>230.00</td>
<td>&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Arc welding helmets 980-4 Ad- Victor justable</td>
<td>&quot;</td>
<td>16.00 Glass</td>
<td>10 yrs</td>
<td>&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50#</td>
<td>General Purpose Electrodes All positions Straight, A.C.</td>
<td>W-20</td>
<td>1/8</td>
<td>&quot;</td>
<td>10.00 No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50#</td>
<td>Electrodes 5/32 for fillets, Flat and Horizontal, Reverse or A.C.</td>
<td>W-24</td>
<td>&quot;</td>
<td>9.50</td>
<td>&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25#</td>
<td>Cast Iron Electrodes Straight or A.C.</td>
<td>W-83</td>
<td>1/8</td>
<td>16.00</td>
<td>&quot;</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table XXII (Continued)

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Item</th>
<th>No.</th>
<th>Size</th>
<th>Manufacturer or Brand</th>
<th>Equipment</th>
<th>Supplies</th>
<th>Replacement</th>
</tr>
</thead>
<tbody>
<tr>
<td>25#</td>
<td>Build Up Rod for Machining Straight</td>
<td>M</td>
<td>1/8</td>
<td>Victor</td>
<td></td>
<td></td>
<td>No</td>
</tr>
<tr>
<td>100</td>
<td>Carbon Electrodes</td>
<td></td>
<td>3/16 x</td>
<td>12&quot;</td>
<td></td>
<td></td>
<td>5.50</td>
</tr>
<tr>
<td>2</td>
<td>G.E. Weld Gauge Sets</td>
<td>92 x</td>
<td></td>
<td>General Electric</td>
<td></td>
<td></td>
<td>3.00 No</td>
</tr>
<tr>
<td>2</td>
<td>Arc hand Shields</td>
<td>172</td>
<td>Full</td>
<td>Sellstrom</td>
<td>10.00</td>
<td></td>
<td>10 yrs.</td>
</tr>
<tr>
<td>3</td>
<td>Folding arc Hand Shields</td>
<td>12</td>
<td></td>
<td>Victor</td>
<td>6.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Leather Gloves</td>
<td>1</td>
<td></td>
<td></td>
<td>7.50</td>
<td></td>
<td>2 yrs.</td>
</tr>
<tr>
<td>2</td>
<td>Arc welding Tables and Booths</td>
<td></td>
<td></td>
<td>Instructor and Students</td>
<td>15.00</td>
<td></td>
<td>No</td>
</tr>
<tr>
<td>1</td>
<td>Guided bend Test Jig</td>
<td></td>
<td></td>
<td></td>
<td>5.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Free Bend Test Jig</td>
<td></td>
<td></td>
<td></td>
<td>2.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td></td>
<td></td>
<td></td>
<td>747.00</td>
<td>57.00</td>
<td></td>
</tr>
</tbody>
</table>
General Shop Equipment

To complete the equipment list for the proposed high school general metal shop, the following items should be added to the welding equipment listed above.

The shop described and equipped here is only suggestive of an actual situation. The prices quoted are approximations and for general evaluation of new equipment. The list is probably not complete in every sense, and it is possible that many instructors would disagree as to manufacturers. It is intended that this breakdown of a general metal shop would be of some use to those interested in comparing shops on the basis of cost of installation. It should also be helpful to those who plan to improve present facilities.
### Table XXIII
Equipment and Approximate Prices for a General Metal Shop, Not Including Welding

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Item</th>
<th>Size</th>
<th>Manufacturer</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Machine Shop Area</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Milling Machine</td>
<td>2</td>
<td>Van Norman</td>
<td>4500.00</td>
</tr>
<tr>
<td>1</td>
<td>Shaper</td>
<td>12&quot; stroke</td>
<td>Cincinnati</td>
<td>1200.00</td>
</tr>
<tr>
<td>5</td>
<td>Lathes, Screw Cutting Quick Change Gear Box</td>
<td>13&quot; swing 4' bed</td>
<td>South Bend</td>
<td>4500.00</td>
</tr>
<tr>
<td>1</td>
<td>Combination Grinder-1HP Long Shaft for Buffing</td>
<td>1-1/8&quot; shaft</td>
<td>Cincinnati</td>
<td>180.00</td>
</tr>
<tr>
<td>1</td>
<td>Grinder 1/2 HP</td>
<td>3/4&quot; shaft</td>
<td>Cincinnati</td>
<td>110.00</td>
</tr>
<tr>
<td>1</td>
<td>Drill Press</td>
<td></td>
<td>Delta</td>
<td>150.00</td>
</tr>
<tr>
<td>1</td>
<td>Drill Press</td>
<td></td>
<td>Walker-Turner</td>
<td>150.00</td>
</tr>
<tr>
<td>1</td>
<td>Power Hack Saw</td>
<td></td>
<td></td>
<td>125.00</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td></td>
<td></td>
<td>10915.00</td>
</tr>
</tbody>
</table>

| **Sheet Metal Area** |                                |               |              |       |
| 1        | Floor shear, bar cutting       | 7" blades 3/4" cap. | Edwards | 64.00  |
| 1        | Slitting shear, 1/4" capacity | 4" blade      | Pexto       | 78.00  |
| 1        | Box & Pan Brake, 16 gal. capacity | 4'        | Pexto       | 320.00 |
| 1        | Bar folder                      | 30"          | Pexto       | 146.00 |
Table XXIII (Continued)

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Item</th>
<th>Size</th>
<th>Manufacturer</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Slip Forming Rolls</td>
<td>37&quot;</td>
<td>Pexto</td>
<td>227.00</td>
</tr>
<tr>
<td>1</td>
<td>Squaring Shear</td>
<td>3'</td>
<td>Pexto</td>
<td>300.00</td>
</tr>
<tr>
<td>1</td>
<td>18 ga. capacity</td>
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<td></td>
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<tr>
<td>6</td>
<td>Stakes (Beakhorn,</td>
<td></td>
<td>Pexto</td>
<td>50.00</td>
</tr>
<tr>
<td></td>
<td>Blowhorn, Needle-case</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hatchet, Double Seaming Square)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Crimping machine</td>
<td>20 ga.</td>
<td>Pexto</td>
<td>54.00</td>
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<tr>
<td>1</td>
<td>Beading machine</td>
<td>20 ga.</td>
<td>Pexto</td>
<td>54.00</td>
</tr>
<tr>
<td>1</td>
<td>Wiring machine</td>
<td>20 ga.</td>
<td>Pexto</td>
<td>47.00</td>
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<tr>
<td>1</td>
<td>Burring machine</td>
<td>22 ga.</td>
<td>Pexto</td>
<td>39.00</td>
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<tr>
<td>1</td>
<td>Whitney Hand Punch-(\frac{1}{4})&quot; capacity</td>
<td>Whitney</td>
<td>16.00</td>
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<td></td>
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</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td></td>
<td></td>
<td>1395.00</td>
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</table>

Forge, Foundry, and Heat Treating Areas

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Item</th>
<th>Size</th>
<th>Manufacturer</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Anvils, Swedish</td>
<td>150#</td>
<td>Parker</td>
<td>50.00</td>
</tr>
<tr>
<td></td>
<td>Steel-Hardened,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Steel Face</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Forge with Elec.</td>
<td></td>
<td>Buffalo</td>
<td>90.00</td>
</tr>
<tr>
<td></td>
<td>Blower</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Crucible Furnace</td>
<td>7&quot; d. x 10&quot;</td>
<td>Johnson</td>
<td>60.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Crucible</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Heat Treating Furnace</td>
<td>12&quot;x12&quot;x12&quot;</td>
<td>Instructor and Students</td>
<td>5.00</td>
</tr>
</tbody>
</table>
Table XXIII (Continued)

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Item</th>
<th>Size</th>
<th>Manufacturer</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Bench Furnaces</td>
<td>4&quot;x4&quot;x5&quot;</td>
<td>Johnson</td>
<td>45.00</td>
</tr>
<tr>
<td></td>
<td>2 Burner</td>
<td>I.D.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td></td>
<td></td>
<td>250.00</td>
</tr>
</tbody>
</table>

General Equipment

| 1        | Electric Hand Drill-Heavy Duty | 3/4" cap. | Black & Decker | 45.00 |
|          | Electric Hand Drill-Heavy Duty with Morse Taper Chuck | 5/8" cap. | Black & Decker | 60.00 |
| 1        | Combination Portable Elec. Grinder and Disc Sander Heavy duty | No. 7     | Black & Decker | 35.00 |
| 5        | Bench vises      | 6" opening | Parker       | 150.00|
|          | 4" jaws          |            |              |      |
|          | TOTAL            |            |              | 340.00|

Hand tools common to all areas 500.00
TABLE XXIV
Total Approximate Costs for a General Metal Shop Installation

<table>
<thead>
<tr>
<th>Areas</th>
<th>Equipment</th>
<th>Supplies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxyacetylene welding</td>
<td>589.25</td>
<td>116.30</td>
</tr>
<tr>
<td>Arc welding</td>
<td>747.00</td>
<td>57.00</td>
</tr>
<tr>
<td>Total for welding</td>
<td>1336.25</td>
<td>173.30</td>
</tr>
<tr>
<td>Machine shop</td>
<td>10915.00</td>
<td></td>
</tr>
<tr>
<td>Sheet metal</td>
<td>1395.00</td>
<td></td>
</tr>
<tr>
<td>Forge, foundry, heat treating</td>
<td>250.00</td>
<td></td>
</tr>
<tr>
<td>General Equipment</td>
<td>340.00</td>
<td></td>
</tr>
<tr>
<td>Hand tools common to areas</td>
<td>500.00</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>13400.00</td>
<td></td>
</tr>
</tbody>
</table>

The tentative list shown above is descriptive of the necessary tools and equipment for a general metal shop. This information on welding equipment has been collected from catalogs supplied by manufacturers listed in The Welding Encyclopedia (8: p. 881-965). The remainder of the information on other tools and equipment has been selected from publications by manufacturers advertising in the Industrial Arts and Vocational Education Magazine, a leading professional journal. All prices are approximate and are subject to change by the manufacturer without notice.
Calculating the Cost of Materials Used in Welding

The expense of oxyacetylene welding is based on the cost of the rods used, plus the cost of acetylene and oxygen consumed. The amount of flux expended in a school shop is negligible. Students should be thoroughly familiar with the operating expenses, and how to figure the cost of welding jobs. To do this, the student should be taught to use the standard tables described in this chapter. However, as problems for mathematics classes or advanced shop work, calculation without tables would offer excellent experience.

The simplest method for students to calculate the expense of the rod they use is by working with the following standard table (10:188):

### TABLE XXV

Weights of Round Steel Welding Rods

<table>
<thead>
<tr>
<th>Diameter in Inches</th>
<th>Pounds per Foot</th>
<th>Feet per Pound</th>
<th>Approximate No. of 36&quot; Rods in 50# Bundle</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/16</td>
<td>0.010</td>
<td>96.154</td>
<td>1600</td>
</tr>
<tr>
<td>3/32</td>
<td>0.023</td>
<td>42.735</td>
<td>700</td>
</tr>
<tr>
<td>1/8</td>
<td>0.042</td>
<td>24.038</td>
<td>400</td>
</tr>
<tr>
<td>5/32</td>
<td>0.065</td>
<td>15.376</td>
<td>250</td>
</tr>
<tr>
<td>3/16</td>
<td>0.094</td>
<td>10.672</td>
<td>175</td>
</tr>
<tr>
<td>7/32</td>
<td>0.128</td>
<td>7.237</td>
<td>125</td>
</tr>
<tr>
<td>1/4</td>
<td>0.167</td>
<td>5.999</td>
<td>100</td>
</tr>
<tr>
<td>9/32</td>
<td>0.211</td>
<td>4.739</td>
<td>75</td>
</tr>
<tr>
<td>5/16</td>
<td>0.281</td>
<td>3.331</td>
<td>70</td>
</tr>
<tr>
<td>3/8</td>
<td>0.376</td>
<td>2.660</td>
<td>45</td>
</tr>
</tbody>
</table>
To determine the cost of welding rod used, the student determines from the above table the weight in pounds of the rod he has listed in feet on his cost-of-material card. The cost per pound of the steel rod given is $0.115. This figure, multiplied by the number of pounds used, would give the cost of the welding rod.

The same procedure is used in determining the cost of cast iron rods. However, a different table is used and a different cost per pound—approximately $0.16 per pound at the time of writing (10:189).

TABLE XXVI

Weight per Foot of Cast Iron Welding Rods of Various Sizes and Shapes

<table>
<thead>
<tr>
<th>Size in Inches</th>
<th>Square</th>
<th>Round</th>
<th>Hexagonal</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/16</td>
<td>0.110</td>
<td>0.086</td>
<td>0.095</td>
</tr>
<tr>
<td>1/4</td>
<td>0.195</td>
<td>0.153</td>
<td>0.169</td>
</tr>
<tr>
<td>5/16</td>
<td>0.305</td>
<td>0.239</td>
<td>0.264</td>
</tr>
<tr>
<td>3/8</td>
<td>0.427</td>
<td>0.344</td>
<td>0.380</td>
</tr>
<tr>
<td>1/2</td>
<td>0.780</td>
<td>0.613</td>
<td>0.676</td>
</tr>
</tbody>
</table>

Other special rods require similar tables. In some tables prices are given per foot of rod, rather than by the pound.

Fluxes need not be considered in actual shop practice, as the amounts used are too small to work with for the average school job. Special problems can be given
for experience in figuring the cost of flux on larger jobs.

The determination of the amount of oxygen and acetylene gases used on all welding jobs ought to be a familiar problem to each student. Every pupil should be required to figure the cost of the gases used in each class period, and on all jobs undertaken at other times, keeping a record of the total amount consumed in his work of the entire semester or term. To permit students to use torches and rods without insisting that they calculate the cost of the materials consumed would encourage wastefulness.

There are two methods of arriving at the amount of the gases used. **METHOD I** requires the use of the standard chart showing the amount of gas any particular tip size would consume in an hour, provided the regulators are set properly. With this information, it is a simple matter to compute the welding cost for any length of time, based on the current prices of oxygen (about $0.02 per cubic foot) and acetylene (about $0.035 per cubic foot). The following chart of gas consumption figures is from Plumley (10:p.191):
TABLE XXVII

Table Showing Gas Consumption, Length of Flame, Regulator Pressures, Etc., for Each Size of Tip Assembly

<table>
<thead>
<tr>
<th>Size of Tip Assembly</th>
<th>Thickness of Metal in Inches</th>
<th>Length of Ave. Flame in Inches</th>
<th>Approximate Pressure at Regulators in Pounds per Square Inch</th>
<th>Main Port Drill Size in Inches</th>
<th>Dia. of Main Port in Inches</th>
<th>Approximate Cu. Ft. of Gas Used per Hour</th>
<th>Approx. Number of Lineal Feet Welded per Hour</th>
<th>Size of Tip Assembly</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1/4</td>
<td>1/4</td>
<td>1</td>
<td>1</td>
<td>0.037</td>
<td>5.0</td>
<td>13.0</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>1/8 to 3/8</td>
<td>3/8</td>
<td>2</td>
<td>2</td>
<td>0.042</td>
<td>6.0</td>
<td>18.5—5.8</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>1/8 to 1/4</td>
<td>1/4</td>
<td>2</td>
<td>2</td>
<td>0.055</td>
<td>9.0</td>
<td>12.0</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>1/4 to 3/8</td>
<td>3/8</td>
<td>2</td>
<td>2</td>
<td>0.0635</td>
<td>12.0</td>
<td>12.0</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>3/8 to 1/2</td>
<td>1/2</td>
<td>3</td>
<td>3</td>
<td>0.076</td>
<td>21.0</td>
<td>8.3—7.5</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>1/2 to 5/8</td>
<td>5/8</td>
<td>3</td>
<td>3</td>
<td>0.086</td>
<td>23.0</td>
<td>4.2—2.3</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
<td>5/8 to 1</td>
<td>3/4</td>
<td>4</td>
<td>4</td>
<td>0.098</td>
<td>36.0</td>
<td>3.1—2.0</td>
<td>7</td>
</tr>
<tr>
<td>8</td>
<td>3/4 to 1</td>
<td>1</td>
<td>6</td>
<td>6</td>
<td>0.1065</td>
<td>50.0</td>
<td>2.1—1.7</td>
<td>8</td>
</tr>
<tr>
<td>9</td>
<td>1 and over</td>
<td>7/8</td>
<td>7</td>
<td>7</td>
<td>0.116</td>
<td>58.0</td>
<td>16.0—10.0</td>
<td>9</td>
</tr>
<tr>
<td>10</td>
<td>Heavy Castings</td>
<td>2</td>
<td>8</td>
<td>8</td>
<td>0.1405</td>
<td>100.0</td>
<td>Variable</td>
<td>10</td>
</tr>
<tr>
<td>11</td>
<td>Etc.</td>
<td>9/16</td>
<td>10</td>
<td>10</td>
<td>0.147</td>
<td>106.0</td>
<td>106.0</td>
<td>11</td>
</tr>
<tr>
<td>12</td>
<td></td>
<td>11</td>
<td>11</td>
<td>11</td>
<td>0.1495</td>
<td>108.0</td>
<td>108.0</td>
<td>12</td>
</tr>
</tbody>
</table>
METHOD II involves calculating the amount of gases consumed by use of the cubic foot scale and the pounds per square inch scale on the cylinder pressure gauge of the oxygen regulator. The pressures and volumes given on the acetylene cylinder gauges are not reliable because the pressure-volume ratio of acetylene gas is affected by the fact that the gas is in a dissolved state (in acetone) rather than in the free state like oxygen. Since most welding is accomplished by use of the neutral flame, which consumes approximately equal amounts of oxygen and acetylene, it would be fairly accurate to assume that the number of cubic feet of acetylene used would equal the cubic feet of oxygen, shown by the oxygen gauges.

The full oxygen cylinder contains 220 cubic feet at 2000 pounds pressure. The removal of one cubic foot of gas will reduce the pressure approximately 9 pounds per square inch. Now, assuming the gauges are accurate, it is possible to use the above rules in determining the gas used, within 1/9 of a cubic foot. To do so, it is necessary to record the oxygen cylinder pressure at the beginning of work, to subtract from that the pressure at the end of the job, and to convert the pressure drop to cubic feet, either by simple mathematics or by the use of a standard conversion table (10:p.187):
### TABLE XXVIII

Table Giving the Nearest Even Cubic Feet (Approximate) of Oxygen Contained in a Standard 220 Cubic Foot Cylinder for Each Twenty-five Pound Increment of Gauge Pressure

<table>
<thead>
<tr>
<th>Pressure in Cylinder Lbs/Sq. In. at 70° F.</th>
<th>Cubic Ft at Pressures Given</th>
<th>Pressure in Cylinder Lbs/Sq. In. at 70° F.</th>
<th>Cubic Ft at Pressures Given</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.00</td>
<td>1025</td>
<td>112</td>
</tr>
<tr>
<td>25</td>
<td>3</td>
<td>1050</td>
<td>115</td>
</tr>
<tr>
<td>75</td>
<td>5</td>
<td>1075</td>
<td>118</td>
</tr>
<tr>
<td>100</td>
<td>8</td>
<td>1100</td>
<td>121</td>
</tr>
<tr>
<td>125</td>
<td>11</td>
<td>1125</td>
<td>123</td>
</tr>
<tr>
<td>150</td>
<td>14</td>
<td>1150</td>
<td>126</td>
</tr>
<tr>
<td>175</td>
<td>19</td>
<td>1175</td>
<td>129</td>
</tr>
<tr>
<td>200</td>
<td>22</td>
<td>1200</td>
<td>132</td>
</tr>
<tr>
<td>225</td>
<td>25</td>
<td>1225</td>
<td>134</td>
</tr>
<tr>
<td>250</td>
<td>27</td>
<td>1250</td>
<td>137</td>
</tr>
<tr>
<td>275</td>
<td>30</td>
<td>1275</td>
<td>140</td>
</tr>
<tr>
<td>300</td>
<td>33</td>
<td>1300</td>
<td>143</td>
</tr>
<tr>
<td>325</td>
<td>35</td>
<td>1325</td>
<td>145</td>
</tr>
<tr>
<td>350</td>
<td>38</td>
<td>1350</td>
<td>148</td>
</tr>
<tr>
<td>375</td>
<td>41</td>
<td>1375</td>
<td>151</td>
</tr>
<tr>
<td>400</td>
<td>44</td>
<td>1400</td>
<td>154</td>
</tr>
<tr>
<td>425</td>
<td>46</td>
<td>1425</td>
<td>157</td>
</tr>
<tr>
<td>450</td>
<td>49</td>
<td>1450</td>
<td>159</td>
</tr>
<tr>
<td>475</td>
<td>52</td>
<td>1475</td>
<td>162</td>
</tr>
<tr>
<td>500</td>
<td>55</td>
<td>1500</td>
<td>165</td>
</tr>
<tr>
<td>525</td>
<td>57</td>
<td>1525</td>
<td>168</td>
</tr>
<tr>
<td>550</td>
<td>60</td>
<td>1550</td>
<td>170</td>
</tr>
<tr>
<td>575</td>
<td>63</td>
<td>1575</td>
<td>173</td>
</tr>
<tr>
<td>600</td>
<td>66</td>
<td>1600</td>
<td>176</td>
</tr>
<tr>
<td>625</td>
<td>68</td>
<td>1625</td>
<td>179</td>
</tr>
<tr>
<td>650</td>
<td>71</td>
<td>1650</td>
<td>181</td>
</tr>
<tr>
<td>675</td>
<td>74</td>
<td>1675</td>
<td>184</td>
</tr>
<tr>
<td>700</td>
<td>77</td>
<td>1700</td>
<td>187</td>
</tr>
<tr>
<td>725</td>
<td>79</td>
<td>1725</td>
<td>190</td>
</tr>
<tr>
<td>750</td>
<td>82</td>
<td>1750</td>
<td>192</td>
</tr>
<tr>
<td>775</td>
<td>85</td>
<td>1775</td>
<td>195</td>
</tr>
<tr>
<td>800</td>
<td>88</td>
<td>1800</td>
<td>198</td>
</tr>
<tr>
<td>825</td>
<td>90</td>
<td>1825</td>
<td>201</td>
</tr>
<tr>
<td>850</td>
<td>93</td>
<td>1850</td>
<td>203</td>
</tr>
<tr>
<td>875</td>
<td>96</td>
<td>1875</td>
<td>206</td>
</tr>
<tr>
<td>900</td>
<td>99</td>
<td>1900</td>
<td>209</td>
</tr>
</tbody>
</table>
Temperature is the only other factor to consider in this measurement of the volume of gases. The table above is accurate only if the cylinder temperature is at 70° F. In the event room and cylinder temperatures rise above 90° F. or fall below 50° F., it is necessary to correct for the direct effect of temperature on the volume of gas. The following table from Linde Air Products Company literature is helpful in making this correction (5:3):

Table XXVIII (Continued)

<table>
<thead>
<tr>
<th>Pressure in Cylinder Lbs/Sq. In. at 70° F.</th>
<th>Cubic Ft at Pressures Given</th>
<th>Pressure in Cylinder Lbs/Sq. In. at 70° F.</th>
<th>Cubic Ft at Pressures Given</th>
</tr>
</thead>
<tbody>
<tr>
<td>925</td>
<td>101</td>
<td>1925</td>
<td>212</td>
</tr>
<tr>
<td>950</td>
<td>104</td>
<td>1950</td>
<td>214</td>
</tr>
<tr>
<td>975</td>
<td>107</td>
<td>1975</td>
<td>217</td>
</tr>
<tr>
<td>1000</td>
<td>110</td>
<td>2000</td>
<td>220</td>
</tr>
</tbody>
</table>
### TABLE XXIX

Temperature Correction Factors for Readings on Cubic Foot Scale of Oxygen Gauge

<table>
<thead>
<tr>
<th>Temperature Deg. F.</th>
<th>Increase Reading by Per Cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>-10</td>
<td>25</td>
</tr>
<tr>
<td>0</td>
<td>21</td>
</tr>
<tr>
<td>10</td>
<td>17</td>
</tr>
<tr>
<td>20</td>
<td>14</td>
</tr>
<tr>
<td>30</td>
<td>11</td>
</tr>
<tr>
<td>40</td>
<td>8</td>
</tr>
<tr>
<td>50</td>
<td>5</td>
</tr>
<tr>
<td>60</td>
<td>2</td>
</tr>
<tr>
<td>70</td>
<td>0</td>
</tr>
</tbody>
</table>

Decrease reading by

<table>
<thead>
<tr>
<th>Temperature Deg. F.</th>
<th>Decrease Reading by Per Cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>80</td>
<td>2</td>
</tr>
<tr>
<td>90</td>
<td>5</td>
</tr>
<tr>
<td>100</td>
<td>7</td>
</tr>
</tbody>
</table>

To determine the cost of cutting steel with an oxy-acetylene torch, the most accurate means is to measure the volume of gas by METHOD II. However, there is a standard quick-reference chart which gives an approximation of the gas consumed. In using the Linde Air Products chart (6:p.320), no allowance is made for tip size, tip shape, or the pressure applied by the operator to the
TABLE XXX

Time and Gases Consumed in Cutting Steel

<table>
<thead>
<tr>
<th>Thickness of Metal in Inches</th>
<th>Hand Cutting In./Min.</th>
<th>Gas Consumption Per Min.</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Oxygen Cubic Ft.</td>
<td>Acetylene Cubic Ft.</td>
</tr>
<tr>
<td>1/8</td>
<td>19.9-29.8</td>
<td>0.8-0.9</td>
<td>0.12-0.15</td>
</tr>
<tr>
<td>1/4</td>
<td>17.6-25.8</td>
<td>1.3-1.6</td>
<td>0.15-0.18</td>
</tr>
<tr>
<td>3/8</td>
<td>16.0-23.7</td>
<td>1.6-1.9</td>
<td>0.16-0.20</td>
</tr>
<tr>
<td>1/2</td>
<td>14.8-22.2</td>
<td>1.8-2.1</td>
<td>0.18-0.22</td>
</tr>
<tr>
<td>3/4</td>
<td>13.1-19.8</td>
<td>2.0-2.4</td>
<td>0.20-0.24</td>
</tr>
<tr>
<td>1</td>
<td>11.8-18.0</td>
<td>2.2-2.7</td>
<td>0.22-0.27</td>
</tr>
<tr>
<td>2</td>
<td>8.6-13.0</td>
<td>3.1-3.8</td>
<td>0.27-0.33</td>
</tr>
<tr>
<td>3</td>
<td>6.6-9.8</td>
<td>4.0-4.8</td>
<td>0.31-0.38</td>
</tr>
<tr>
<td>4</td>
<td>5.2-7.8</td>
<td>4.9-6.0</td>
<td>0.35-0.43</td>
</tr>
<tr>
<td>5</td>
<td>4.2-6.4</td>
<td>5.8-7.1</td>
<td>0.40-0.49</td>
</tr>
<tr>
<td>6</td>
<td>3.5-5.4</td>
<td>6.7-8.2</td>
<td>0.44-0.54</td>
</tr>
<tr>
<td>8</td>
<td>2.6-4.2</td>
<td>8.4-10.3</td>
<td>0.53-0.64</td>
</tr>
</tbody>
</table>

Note: Lowest speeds and highest gas consumption per linear foot are for inexperienced operators, short cuts, dirty or poor material. Highest speeds and lowest gas consumption per linear foot are for thoroughly experienced operators, long cuts, clean and good material.
The tables used in this chapter, the current prices on supplies, and visual aids on figuring welding and cutting costs should be placed in convenient places about the school welding shops for student reference. All students should be required, following thorough instruction, to compute costs and keep a record of the materials and supplies consumed during the course.

An example of a good visual aid for a welding shop has been selected from the Linde Air Products Company brochure on figuring welding and cutting costs (5:5):
## TABLE XXXI

### PRICE CARD

<table>
<thead>
<tr>
<th>Make of Blowpipe</th>
<th>Welding Tip No.</th>
<th>Cost of Oxygen and Acetylene Consumed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Per Hour</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cutting Nozzle No.</th>
<th>Oxygen Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

- Steel rod, per lb.
- Cast iron rod, per lb.
- Cast iron flux, per lb.
- Bronze rod, per lb.
- Bronze flux, per lb.
- Aluminum rod, per lb.
- Aluminum flux, per lb.
- Haynes Stellite rod, per lb.

### APPROPRIATE WEIGHTS OF WELDING RODS

In fractions of a pound per linear foot

<table>
<thead>
<tr>
<th>Diam. in.</th>
<th>Haynes Stellite</th>
<th>Steel</th>
<th>Bronze</th>
<th>Copper</th>
<th>Aluminum</th>
<th>Cast Iron</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/16</td>
<td></td>
<td>0.0105</td>
<td>0.0114</td>
<td></td>
<td>0.0056</td>
<td></td>
</tr>
<tr>
<td>5/32</td>
<td></td>
<td>0.0234</td>
<td>0.0253</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/8</td>
<td></td>
<td>0.0416</td>
<td>0.045</td>
<td>0.048</td>
<td>0.014</td>
<td>0.089</td>
</tr>
<tr>
<td>5/16</td>
<td>0.120</td>
<td>0.094</td>
<td>0.101</td>
<td>0.107</td>
<td>0.056</td>
<td>0.150</td>
</tr>
<tr>
<td>5/32</td>
<td>0.200</td>
<td>0.169</td>
<td>0.179</td>
<td>0.190</td>
<td>0.087</td>
<td>0.226</td>
</tr>
<tr>
<td>1/8</td>
<td>0.350</td>
<td>0.265</td>
<td></td>
<td></td>
<td>0.126</td>
<td>0.317</td>
</tr>
<tr>
<td>5/16</td>
<td>0.480</td>
<td>0.382</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
CHAPTER VI

SUMMARY AND RECOMMENDATIONS

Summary

The conclusions resulting from the attempt to solve the problem of the teaching of welding in secondary schools are listed here, not as indisputable facts, but merely statements of the outcome of this study, which is based on fairly reliable sources of information.

1. Material gathered from questionnaires gives evidence that welding is offered to some extent in many of the secondary schools of California; but the survey also indicates that there seems to be very little agreement among the schools as to what constitutes a modern training program in metalwork with welding as the major activity.

2. Many supervisors and educators indicate that this experience with metals and industrial processes very definitely should be a part of every boy's high school education.

3. Many educators and administrators are of the opinion that welding instruction is a valuable experience for students from agricultural areas as well as industrial centers of the state.
4. The data gathered support the opinion that, generally speaking, welding instruction is often not presented by industrial arts teachers because so many are neither familiar with its applications nor skilled in performing this relatively new industrial process.

5. Through a study of cost of installation of a typical general metal shop it was found that the cost of a work station, provided with electric welding equipment, is approximately one and a half to three and a half times more expensive per pupil than one provided with complete oxyacetylene equipment.

6. The cost of one complete oxyacetylene unit is approximately $100.00 for the best quality equipment which may be used in cutting, hardening, softening, bending, and welding virtually all metals. It is suggested that sufficient equipment be available to provide a unit for each student, or, if necessary, one unit for every two students.

7. Electric welding should be secondary to oxyacetylene welding instruction, and the suggested equipment is approximately one electric welding unit per ten pupils. For advanced classes the number of units may be increased if the experience desired justifies the expense.

8. Virtually all of the supervisors and many of
the educators contacted in this study agree that instruction in welding should be a very important part of industrial arts education and should not be left entirely to vocational training.

Recommendations

The following suggestions which arose from this survey and study are offered here with the intention of enriching California's industrial arts program by the inclusion of an important industrial process that could be more universally used in small businesses, on farms, and in leisure time activities, if sufficient instruction were offered in the secondary schools.

1. It would seem advisable for all secondary schools in California to offer thorough instruction in welding in the industrial arts shops and to offer experience in fabricating and repairing metal equipment used in agriculture, in small industries, and in maintenance of a home. Institutions that stress skills by the preparation of welding samples should consider the possibility of offering experience in real problems such as the welding of fenders, cylinder heads, structural steels, worn shafts, and sheet metal and pipe, rather than scrap steel plate.

2. As a means of assisting experienced teachers
and preparing new teachers, the teacher-training institutions should develop a more complete program of instruction in welding, with ample time for instructors to acquire skills and to study the equipment and its uses in industry and agriculture, from the point of view of construction and repairs.

3. It would seem advisable for the members of the industrial arts profession in the state of California to assemble and formulate a state course of study which would include minimum standards of instruction, objectives, and a complete course outline for every industrial arts subject.


APPENDIX A

Copies of Letters and Questionnaires
Dear Sir:

Attached to this letter you will find a questionnaire which is a part of a survey being made to determine just how welding fits into the industrial arts program. The information obtained will be used in a thesis entitled "Welding As A Medium of Instruction for Industrial Arts."

All who participate will be informed of the results of this survey by letter. If the results are unusually noteworthy, there will be a more expanded report in one of our professional journals or magazines.

Enclosed you will find a stamped, self-addressed envelope to aid in the safe return of the completed questionnaire, and an extra copy of the questionnaire that you may wish to keep as a means of comparing your answers with the results of the survey as published.

Your cooperation will be greatly appreciated. It will be particularly helpful if this information is mailed to me prior to June 1, 1947.

Yours truly,

Gordon D. Van Arsdale
Instructor

P.S. Any suggestions or criticisms will be gratefully accepted.
QUESTIONNAIRE

NAME ___________________________ SCHOOL ___________________________

Please answer the following by circling appropriate words in the right hand column, or filling in the blanks, as indicated.

I. Is welding taught in your school? Yes No

II. This section to be answered only if welding is NOT offered:

1. Do you see a need for the teaching of welding? Yes No

2. If you feel there is a need, please re-arrange the following reasons in order of their importance. (Feel free to insert additional reasons.)

   1) General education
   2) Consumer education
   3) Avocational outlet
   4) "Handy-man" ability
   5) Pre-vocational values
   6) Opportunity to create
   7) Knowledge of industrial processes
   8)
   9)

3. For what reasons is welding not offered at your school?

   1) Too expensive
   2) Lack of space
   3) No need
   4) Too dangerous
   5) No trained teacher
6) Administration not in favor
7) __________________________
8) __________________________

III. This section to be answered only if welding is offered:

1. Is welding taught for vocational ends or for industrial arts objectives?

Vocational Industrial Arts

2. If taught from the industrial arts point of view, please re-arrange in order of importance.

1) General education 1) ______________
2) Consumer education 2) ______________
3) Avocational outlet 3) ______________
4) Pre-vocational values 4) ______________
5) "Handy-man" ability 5) ______________
6) Opportunity to create 6) ______________
7) Knowledge of industrial processes 7) ______________
8) ______________
9) ______________

3. Does your community particularly need young men trained in welding?
   Yes
   No

4. Is welding offered in a unit shop or a general shop course?
   Unit
   General shop

5. Approximately how many students study welding during a school year? _____

6. How many boys attend your school? ____
7. Is the student demand for welding instruction large or small?  
   Large  
   Small

8. What is the largest number of students you can handle in a welding class? _____

9. In what grade or grades may students enroll in welding courses? _____

10. How much floor space is devoted to welding in your shop? _____ square feet

11. How many electric welding outfits are you using?

12. How many gas welding units are you using? _____

13. How much money is budgeted annually for welding instruction? _____

14. What projects do your welding classes normally work on?
   1) ________________  5) ________________
   2) ________________  6) ________________
   3) ________________  7) ________________
   4) ________________  8) ________________

15. Do students have an opportunity to do welding in constructing projects of their own? 
   Yes  
   No

Additional comment:
June 2, 1947

Dear Sir:

In this industrial arts department we offer opportunity for students who are training to be shop teachers to acquire a wide variety of experience in woodwork, automotive service, machine shop, mechanical drawing, electricity, printing, and many types of general metalwork. They are prepared to teach in any type of industrial arts shop.

I am an instructor of welding at this institution, and am attempting some research to determine whether or not there is a general need throughout California for welding instruction in the secondary schools. Some schools are offering instruction in welding, while others neglect metal work and stress only woodworking.

I would appreciate your filling in the blanks on the enclosed form and returning it in the self-addressed envelope. Please feel free to offer any suggestions or criticisms. You will be informed of the results of this research by another letter. This information, if valid, will also be passed on to students in future classes here.

Yours truly,

Gordon D. Van Arsdale
SUPERINTENDENT'S QUESTIONNAIRE

Name __________________________
School district ______________________

1. How many schools in your school district offer some instruction in welding?....._______ out of ______

2. How many schools in your school district have welding equipment?.................. ______

3. How many schools in your school district have instructors capable of teaching welding?... ______

4. Do you believe that welding should be offered only in vocational schools? (yes or no)........ ______

5. Do you believe that welding should be offered in the industrial arts shops of all our secondary schools?................................. ______

6. What is your opinion (pro or con) of offering some form of welding instruction in the industrial arts program of most large secondary schools? (Please give reasons)

I will inform you of the results of this questionnaire, and you may compare them with your duplicate response form. Thank you for your cooperation.
Dear Sir:

Industrial arts shop teachers are trained at this institution to teach in the school shops throughout California. The curriculum offers opportunity for students to develop skill in the use of machines, materials, and equipment used in industry, and acquire knowledge of many industrial processes.

This is not a vocational school, as we do not give specific trade training. We do offer a wide variety of experiences in woodwork, automotive service, machine shop, mechanical drawing, electricity, and many types of metal work, so that students are prepared to teach in any type of industrial arts shop.

I am doing some research to determine whether or not welding should be offered more universally in the secondary schools of California, and the purpose of this letter is to secure data on the following items:

1. Setting up a school welding shop
2. Type of equipment for school welding shops
3. Cost of welding equipment
4. Safety of welding equipment
5. Floor space required for welding equipment
6. Cost of supplies and maintenance
7. Statistics on industrial need for welders

Any information on the above items or suggestions that may come to mind will be very helpful to me and my students, and greatly appreciated by us.

Yours truly,

Gordon D. Van Arsdale
SOCIAL AND ECONOMIC STATISTICS

The United States

The position of the United States in world production is evident through comparison of the amount of steel we produce with the amounts produced in other countries, as listed by Moody\(^1\) in his study of American and foreign investments.

### TABLE I

Pre-War World Production of Steel 1939

(Figures represent long tons)

<table>
<thead>
<tr>
<th>Country</th>
<th>Tonnage</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S.A.</td>
<td>47,533,000</td>
</tr>
<tr>
<td>Germany</td>
<td>24,000,000</td>
</tr>
<tr>
<td>Russia</td>
<td>18,500,000</td>
</tr>
<tr>
<td>Great Britain</td>
<td>13,500,000</td>
</tr>
<tr>
<td>France</td>
<td>8,400,000</td>
</tr>
<tr>
<td>All others</td>
<td>18,250,000</td>
</tr>
<tr>
<td><strong>TOTAL:</strong></td>
<td><strong>134,983,000</strong></td>
</tr>
</tbody>
</table>

The tonnage of steel that a nation is capable of producing is a good indication of that country's strength as a world power, its progress in technology, and its development as a civilized state. The nations whose steel production is relatively small are usually not great

---

APPENDIX B

Industrial Statistics
powers, because they lack iron or coal deposits or because they lack the knowledge and technology to process the iron they possess.

Moody\textsuperscript{1}, in cooperation with technicians of the American Iron and Steel Corporation, has compiled statistics showing how this tremendous amount of raw material is distributed to various industries:

\begin{table}
\centering
\begin{tabular}{|l|c|}
\hline
Distribution & Tonnage \\
\hline
Agricultural equipment & 1,120,000 \\
Autos and airplanes & 2,464,000 \\
Buildings and bridges & 4,664,000 \\
Exports & 3,793,000 \\
Machinery and tools & 2,426,000 \\
Metal containers & 4,333,000 \\
Mining & 2,273,000 \\
Miscellaneous & 31,048,000 \\
Railroads & 5,121,000 \\
\hline
\end{tabular}
\caption{U. S. Distribution of Finished Steel 1945}
\end{table}

California

A study of industrial education in California schools without an explanation of the industrial system of the state would be incomplete. The Sixteenth Census Report of the United States\textsuperscript{2} gives the following facts on labor

\textsuperscript{1}Ibid.

and industry:

TABLE III
California Industrial Employment

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total employed in all industries</td>
<td>1,891,017</td>
<td>634,264</td>
</tr>
<tr>
<td>Total employed in iron and steel industries</td>
<td>23,062</td>
<td>1,711</td>
</tr>
<tr>
<td>Total employed in manufacturing</td>
<td>349,807</td>
<td>67,104</td>
</tr>
</tbody>
</table>

The total number of people employed in manufacturing are employed in the following jobs:

TABLE IV
Major Occupation Groups and Numbers Employed in Manufacturing

<table>
<thead>
<tr>
<th>Groups</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Professional and semi-professional</td>
<td>18,145</td>
</tr>
<tr>
<td>Officials, proprietors, managers</td>
<td>27,844</td>
</tr>
<tr>
<td>Clerical and sales</td>
<td>54,013</td>
</tr>
<tr>
<td>Craftsmen and foremen</td>
<td>98,606</td>
</tr>
<tr>
<td>Operators, including welders</td>
<td>105,453</td>
</tr>
<tr>
<td>Protective service workers</td>
<td>3,057</td>
</tr>
<tr>
<td>Service workers</td>
<td>2,504</td>
</tr>
<tr>
<td>Laborers</td>
<td>39,032</td>
</tr>
<tr>
<td>Total:</td>
<td>349,807</td>
</tr>
</tbody>
</table>

The largest occupational group in manufacturing is the force of "operators," which includes machine tool operators and welders. The number of persons employed as welders and flame cutters in the leading cities of California are listed as follows:
TABLE V

Number of Welders and Flame Cutters Employed in California Industrial Cities

<table>
<thead>
<tr>
<th>City</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Los Angeles</td>
<td>1,759</td>
</tr>
<tr>
<td>Oakland</td>
<td>646</td>
</tr>
<tr>
<td>San Francisco</td>
<td>538</td>
</tr>
<tr>
<td>Other cities</td>
<td>6,876</td>
</tr>
<tr>
<td>Total:</td>
<td>9,709</td>
</tr>
</tbody>
</table>

The report of the number of welders in the cities includes only those in the trade or members of the welders union. Many skilled men who use the welding and cutting processes in other trades are not listed.

Federal Vocational Training Program for War Production

The National Defense Training Program was initiated in July, 1940, to train workers for defense industries. At the outbreak of the war this nation was deficient in skilled labor, and industrial production had been at a low ebb for years. A reservoir of 10 million unemployed, excluding those eligible for service and including those not drafted, was a saving factor. The problem was to train these men to fill jobs in modern industry that was to operate at top production. It is enlightening to examine the Federal Security Agency's report on the type of

instruction that had to be offered to these men before they could be used.

TABLE VI
Enrollment in Pre-employment Courses Offered in Defense Training July, 1940, to June, 1945

<table>
<thead>
<tr>
<th>Type of Course</th>
<th>1941</th>
<th>1942</th>
<th>1943</th>
<th>1944</th>
<th>1945</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automotive</td>
<td>30,735</td>
<td>23,112</td>
<td>6,023</td>
<td></td>
<td>5,706</td>
</tr>
<tr>
<td>Aviation</td>
<td>100,247</td>
<td>279,276</td>
<td>232,376</td>
<td>34,144</td>
<td>9,813</td>
</tr>
<tr>
<td>Electrical</td>
<td>18,942</td>
<td>18,657</td>
<td>11,803</td>
<td>4,265</td>
<td>2,559</td>
</tr>
<tr>
<td>Forging</td>
<td>2,420</td>
<td>2,901</td>
<td>1,592</td>
<td></td>
<td>789</td>
</tr>
<tr>
<td>Foundry</td>
<td>5,092</td>
<td>8,518</td>
<td>5,016</td>
<td>431</td>
<td>208</td>
</tr>
<tr>
<td>Machine shop</td>
<td>133,548</td>
<td>264,402</td>
<td>301,030</td>
<td>49,261</td>
<td>15,815</td>
</tr>
<tr>
<td>Radio</td>
<td>5,197</td>
<td>17,710</td>
<td>32,620</td>
<td>16,633</td>
<td>11,313</td>
</tr>
<tr>
<td>Sheet metal</td>
<td>16,894</td>
<td>33,542</td>
<td>21,480</td>
<td>1,800</td>
<td>501</td>
</tr>
<tr>
<td>Shipbuilding</td>
<td>13,378</td>
<td>159,969</td>
<td>200,126</td>
<td>51,412</td>
<td>12,045</td>
</tr>
<tr>
<td>Welding</td>
<td>41,327</td>
<td>99,624</td>
<td>210,842</td>
<td>30,362</td>
<td>9,329</td>
</tr>
<tr>
<td>Other</td>
<td>52,750</td>
<td>64,836</td>
<td>65,836</td>
<td>14,153</td>
<td>13,852</td>
</tr>
<tr>
<td>Total:</td>
<td>420,530</td>
<td>972,562</td>
<td>984,744</td>
<td>208,956</td>
<td>30,657</td>
</tr>
</tbody>
</table>

According to the Federal Security Agency Report, the state that trained the greatest number of defense workers enrolled in pre-employment and supplementary work was California, with an enrollment of 911,392 for the period of July, 1940, to June, 1945. Second to California was New York, with a total of 757,271 enrolled for the same period. The various courses in which men were trained and the total number of those enrolled are an indication of what type of skilled men were needed during

---

1 Ibid., p. 156
the emergency period. This training, of course, was all vocational, but the figures illustrate the demands that industry made and will continue to make.

TABLE VII
Enrollment in Pre-employment Courses Offered in the California Defense Training Program July, 1940, to June, 1945

<table>
<thead>
<tr>
<th>Type of course</th>
<th>Cumulative enrollment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automotive</td>
<td>998</td>
</tr>
<tr>
<td>Aviation</td>
<td>107,193</td>
</tr>
<tr>
<td>Electrical</td>
<td>470</td>
</tr>
<tr>
<td>Forging</td>
<td>57</td>
</tr>
<tr>
<td>Foundry</td>
<td>450</td>
</tr>
<tr>
<td>Machine shop</td>
<td>25,265</td>
</tr>
<tr>
<td>Radio</td>
<td>2,981</td>
</tr>
<tr>
<td>Sheet metal</td>
<td>2,979</td>
</tr>
<tr>
<td>Ship Building</td>
<td>120,194</td>
</tr>
<tr>
<td>Welding</td>
<td>20,192</td>
</tr>
<tr>
<td>Other</td>
<td>16,898</td>
</tr>
<tr>
<td>All courses</td>
<td>237,667</td>
</tr>
</tbody>
</table>

The state expenditures for this instruction were given in the same Federal Security Agency report:\(^1\):

TABLE VIII
Expenditures for Vocational Education and the National Defense Program in California

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Supervision</td>
<td>$ 3,102,772.78</td>
</tr>
<tr>
<td>Instruction</td>
<td>22,445,268.19</td>
</tr>
<tr>
<td>Rental of space</td>
<td>289,800.29</td>
</tr>
<tr>
<td>Equipment</td>
<td>4,201,111.09</td>
</tr>
<tr>
<td>TOTAL:</td>
<td>30,038,952.35</td>
</tr>
</tbody>
</table>

\(^1\)Ibid., p. 176.
<table>
<thead>
<tr>
<th>Types of Manufacture</th>
<th>0</th>
<th>2</th>
<th>4</th>
<th>6</th>
<th>8</th>
<th>10</th>
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<tr>
<td>Textile</td>
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</tr>
<tr>
<td>Iron and steel</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Food</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Apparel</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Machinery, Non-elec.</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Autos</td>
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<tr>
<td>Lumber</td>
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<tr>
<td>Leather</td>
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<tr>
<td>Printing</td>
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<tr>
<td>Furniture</td>
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<tr>
<td>Chemicals</td>
<td></td>
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<tr>
<td>Stone, clay, glass</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Machinery, Elec.</td>
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<td></td>
</tr>
<tr>
<td>Paper</td>
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<td>Miscellaneous</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Metals, Non-ferrous</td>
<td></td>
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</tr>
<tr>
<td>Transportation</td>
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<tr>
<td>Rubber</td>
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<tr>
<td>Petroleums</td>
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<td></td>
</tr>
<tr>
<td>Tobacco</td>
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</tbody>
</table>

APPENDIX C

Proposed Course of Study in
Welding for Secondary Schools in California
PROPOSED COURSE OF STUDY

INTRODUCTION

The foregoing study has concluded that secondary schools should offer the opportunity for students to acquire some degree of skill in the processes of welding common metals, and to explore the possibilities of using metals in industries, on the farm, and in the home.

The purpose of the plan suggested here is to add more of life's real experiences to industrial arts by attempting to satisfy those four native impulses listed by Bonser, the manipulative, the investigative, the art and the social. The program set up here is not complete in units, nor are the lesson plans ready for immediate duplication. However, this outline and bibliography should prove helpful to a welding instructor in designing a given course for his particular situation.

It has been the author's opportunity to attend two of California's high schools and one state college, with an objective of teaching industrial arts. This program of training has offered several opportunities to work in

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various school laboratories on all levels and to visit a
great many of the school shops in California, as well as a
few in Oregon. These and other experiences in teaching,
both in secondary schools and in a teacher-training insti-
tution, have convinced the author that the physical appear-
ance of school shops and the organization as well as pre-
sentation of subject matter is a direct reflection of the
shop teacher's training and ability.

The author's knowledge and skill in welding has been
acquired over a period of years, beginning with a brief
high school introduction to the process, then considerable
experience and self-teaching on the family ranch, followed
by four quarters of excellent college instruction, a year
of night school adult training, and finally a graduate
course on the subject. His industrial knowledge of welding
has been gained through field trips, motion pictures, a
growing interest in industrial publications, and in practi-
cal experience while he was in the service of the U. S. Navy
as a qualified deep sea diver and mine recovery officer. A
tour of duty of Navy repair bases, of experimental stations,
and even at sea has greatly strengthened the author's con-
viction of the importance of welding to all industries
using iron, steel, and special alloys.
This course is not to be entirely a "burning and melting period," the name given to classes in welding in which the student devotes weeks of time to the monotonous task of preparing a sample that the instructor considers as a good job, then repeating the same on another and another test sample until the semester is over. Its purpose is to reduce to a minimum the time spent on producing excellent welds on scrap metal, and to stress repairs on school equipment, farm equipment, bicycles, automobiles, or group problems; it is also to provide opportunity for construction of functional projects in steel, aluminum, brass or copper, with consideration for good design. These accomplishments, and a knowledge of their relationship to similar industrial processes, should provide each student with conclusive evidence of his desirable progress.

**Specific Objectives**

1. To develop a sufficient amount of technical knowledge and skill in working with common metals to keep his home or his farm and its equipment in repair, or to take a temporary job as a metalworker in the event of his losing his regular job.

2. To develop an ability to estimate labor costs and to buy and use metals and metal products more intelligently.
3. To develop an appreciation of neat, orderly, and accurate workmanship in welding and metalwork and an acquaintanceship with the industrial welder and his work.

4. To encourage students to develop a leisure-time activity in welding or related metalwork.

5. To enable each student to perform jobs that offer a feeling of satisfaction in being able to cut, form, and join metal into usable products of functional design.

6. To develop an understanding of the occupational and educational possibilities offered in metalworking industries.

7. To develop a knowledge of the source of ores, the process of refining to metals, and the importance of metals to current economic life.

8. To develop a perception of many social, economic, and industrial problems through a relationship between academic studies, real experiences in the school shop, and industrial visits or "field trips."

9. To offer an opportunity for the development of ability to create artistically with metals.

10. To develop an ability to use abrasives in polishing metals and to apply common industrial metal finishes.
The Class

Any high school student will be able to do the work outlined. It is quite probable that each student has a problem or welding job of his own, growing out of his means of transportation, a hobby, or a new construction project. Freshmen and sophomores probably should be in one class, while the juniors and seniors with their larger problems and more mature interests would best be handled in a separate class. No student should be required to take this work unless it is suggested as fulfilling an individual need. In an ideal situation the class will sell itself, with the help of former students and their exhibited projects.

Pre-requisites

There would be no pre-requisite except the student's desire to do manipulative work with definite objects in mind to construct or problems to solve. The latter should be plentiful. Training will start with common hand tools and work up to the more complex machines and processes.

The material to be covered and the skills to be developed require a daily class for a minimum of one hour, throughout a full school year. The students must be aware
of the fact that welding is an art which everyone can
master, with instruction, in a reasonable amount of time.
Some become proficient at both electric and oxyacetylene
welding; others can master only one technique, and a few
have difficulty performing either process well. The
degree of skill is not as important in the early stages
as is the learning of correct procedures.

The Shop

Cox\(^1\) recommends 65 to 85 square feet per pupil for
the space requirements in a general metal shop. The
floors should be concrete in order to resist sparks and
hot metal.

If at all possible, it is suggested that the shop
have a large double door as an entrance for automobiles
to be welded or fitted with trailer hitches.

For handling blocks, cylinder heads, or agricultural
implements, an overhead track supporting a one-ton chain
hoist will prove to be very helpful.

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Materials

The stock of metals required for this course would consist mostly of hot rolled iron in flats, squares, rounds, and angles, and a few special shapes such as channel, tee, and "I" beam.

Material for hardened steel projects would consist of 85 point carbon octagon tool steel in several sizes and a small quantity of drill rod in standard sizes for special problems.

Aluminum, brass, and copper in sheets and bar stock for working experience in one or two projects should be on hand.

Scrap cast iron, aluminum, and steel in good clean condition would be stocked for welding lessons only. Used scrap would be sold at the end of the year or exchanged for a new supply. The metal selected must always be of a composition that permits welding without difficulty.

With the cooperation of local businesses the instructor might obtain particular types of junked metals for use in special exercises. For body and fender work a local wrecking yard would provide portions of automobiles for welding, soldering, and finishing. Experience in building up gear teeth might be furnished by a large cast iron or steel gear
with several broken teeth. Pipe welding and bending exercises can be offered on short lengths of pipe obtained from a junk yard. One piece of a drag chain would afford excellent material for patching and building up broken links. For practice in building up shafts, short pieces furnish the same problem as a long piece. Many large contractors would be agreeable to providing an efficient school shop with rods and teeth or blades to be hard surfaced.

For projects the students are entitled to the best grade of new metal and should not be required to use scrap. The cost of steel is not prohibitive, and most students can afford to use plenty of this material. Non-ferrous metals are expensive and should be used only in small problems.

The cost of materials and gases is to be determined by each student as a class lesson. The bills are to be settled in two or three installments throughout the year. The cost of material should be kept to a minimum and in some cases shared by the school. In the latter event, students would still figure costs but use a lower base price.

Another means of lowering the cost of materials for each student is for the group to design a useful article
such as a door knocker, foot scraper, or house numbers, and produce several to be sold by the class for equal profits.

**Tools and Equipment**

The following list is suggestive of the equipment needed to conduct the course for twenty students:

**TABLE X**

Tools and Equipment for a Class of Twenty

<table>
<thead>
<tr>
<th>Number</th>
<th>Tools and Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 (or one apiece)</td>
<td>Oxyacetylene outfits</td>
</tr>
<tr>
<td></td>
<td>a. Tips</td>
</tr>
<tr>
<td></td>
<td>b. Cutting attachment</td>
</tr>
<tr>
<td></td>
<td>c. Goggles</td>
</tr>
<tr>
<td></td>
<td>d. Lighters</td>
</tr>
<tr>
<td></td>
<td>e. Regulators and hose</td>
</tr>
<tr>
<td></td>
<td>f. Welding bench</td>
</tr>
<tr>
<td>2 (or 3)</td>
<td>Arc welding outfits</td>
</tr>
<tr>
<td></td>
<td>a. Generator or transformer</td>
</tr>
<tr>
<td></td>
<td>b. Helmet</td>
</tr>
<tr>
<td></td>
<td>c. Gloves</td>
</tr>
<tr>
<td></td>
<td>d. Welding bench and booth</td>
</tr>
<tr>
<td>1 (5 KVA)</td>
<td>Resistance welder (spot) with extra tips</td>
</tr>
<tr>
<td>2 (1 H. P.)</td>
<td>Grinders</td>
</tr>
<tr>
<td></td>
<td>a. One for buffing and polishing</td>
</tr>
<tr>
<td></td>
<td>b. One for grinding and wire brush</td>
</tr>
<tr>
<td>Number</td>
<td>Tools and Equipment</td>
</tr>
<tr>
<td>--------</td>
<td>--------------------------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>Drill press</td>
</tr>
<tr>
<td></td>
<td>a. Chuck</td>
</tr>
<tr>
<td></td>
<td>b. Tapered shank drills to 1&quot;</td>
</tr>
<tr>
<td>1 (16 ga. cap.)</td>
<td>Box and pan brake</td>
</tr>
<tr>
<td>1 (20 ga. cap.)</td>
<td>Bar folder</td>
</tr>
<tr>
<td>1 (16 ga. cap.)</td>
<td>Squaring shear</td>
</tr>
<tr>
<td>1</td>
<td>Bar stock floor shear</td>
</tr>
<tr>
<td>1 ((\frac{1}{2})&quot; cap.)</td>
<td>Slitting shear</td>
</tr>
<tr>
<td>1 (16 ga. cap.)</td>
<td>Throatless circular shear</td>
</tr>
<tr>
<td>1</td>
<td>Power hack saw</td>
</tr>
<tr>
<td>3</td>
<td>Forges</td>
</tr>
<tr>
<td></td>
<td>a. Tongs</td>
</tr>
<tr>
<td></td>
<td>b. Swage block</td>
</tr>
<tr>
<td></td>
<td>c. Anvils</td>
</tr>
<tr>
<td></td>
<td>d. Blacksmith's cone</td>
</tr>
<tr>
<td>1</td>
<td>Bender, Hosfield</td>
</tr>
<tr>
<td></td>
<td>a. Guides for pipe</td>
</tr>
<tr>
<td></td>
<td>b. Guides for angles</td>
</tr>
<tr>
<td></td>
<td>c. Guides for rounds and flats</td>
</tr>
<tr>
<td>3</td>
<td>Bench furnaces</td>
</tr>
<tr>
<td></td>
<td>a. Soldering</td>
</tr>
<tr>
<td></td>
<td>b. Heat treating</td>
</tr>
<tr>
<td></td>
<td>c. Annealing</td>
</tr>
</tbody>
</table>
TABLE X (Continued)

<table>
<thead>
<tr>
<th>Number</th>
<th>Tools and Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Portable grinder</td>
</tr>
<tr>
<td></td>
<td>a. Disc sanding attachment</td>
</tr>
<tr>
<td></td>
<td>b. Grinding wheels</td>
</tr>
<tr>
<td></td>
<td>c. Wire wheel</td>
</tr>
</tbody>
</table>
| 2 (\(\frac{1}{4}\)" and \(\frac{1}{2}\)"
  heavy duty) | Electric drills |
| 1 (\(\frac{1}{4}\)" cap.) | Hand punch |
|        | a. Dies 1/16" to 1/2"
|        | b. Adjustable guide |
| 1 (\(\frac{1}{2}\)" cap.) | Bolt cutter, diagonal, heavy duty |
| 1      | Complete supply of hand tools |
METHODS OF INSTRUCTION

In the shop a demonstration and discussion area should be arranged semicircularly with chairs on a two- or three-step platform. The purpose, of course, is to provide maximum visibility for all pupils who are seated and to eliminate restlessness during demonstrations. The space beneath the platform might be utilized as a divided stock rack. Approximately equidistant from all students would be located a demonstration bench with complete oxyacetylene welding equipment, vise, instructor's hand tools, and a nearby forge for lessons in forging. One hour weekly is to be set aside for demonstrations, discussions, tests, problem study, field trips, or motion pictures.

All written instructional material is to be presented in the form of information, operation, job, and assignment sheets. These instruction sheets are to be written in simple language, well illustrated, and mimeographed to be issued as lessons or supplements to demonstrations. Each student should be required to keep all sheets in a notebook. Several of the lessons assigned will require reference work in the history of welding, the chemistry of welding, the mathematics of welding, or the economics of welding as a means of relating shop and academic studies.
Additional work in the nature of a class report, a scrap book, or a written paper on such subjects as hobbies, jobs at home, repairs on a bicycle, or how to earn money through metalwork would prove beneficial and may create more class interest.

As a means of guiding students through a definite schedule of operations, a glass-covered, centrally located progress chart with all required jobs and lessons listed is effective. At the end of the time assigned for a project, each student submits his lesson or work to the instructor for grading, and his score is placed on the progress chart. Prior to offering his weld sample or project for evaluation, the student should have every opportunity to compare his work with samples of good, average, and poor work that have been prepared by the teacher in virtually every type of welding, cutting, and related jobs done in the shop. Having students compare their own work with the visual aid standards of workmanship is helpful in assigning grades that are neither too low to discourage or too high to cause students to relax and become overconfident. On this same chart the students' attendance, extra work, and test scores might well be recorded.

The most efficient method of recording the amounts and costs of material used is to insist that each student keep
his own records of quantity and cost of gases consumed, as well as the amount, weight, and price of materials he has used. The instructor should check the purchase of most of the material and approve the student's bill at least weekly. Records are to be made out on two printed form cards, 5 x 7 size, one copy for the teacher's desk file and the other for the classroom file.

The clean-up period, usually the last ten minutes of the class time, is to be efficiently conducted and considered as a part of regular instruction. At the end of the working period, all tools are to be turned in at the tool panel, and every student is then to direct his attention to shop cleaning. The pupil should spend the first portion of the clean-up period in cleaning his own work space, and devote the remainder of the time to helping with the straightening of the entire shop. Students should not be required to sweep the floors except as punishment for shirking responsibility. All machines and equipment are to be wiped from top to base and machined surfaces coated with a film of oil. The most efficient and educational method of conducting the general clean-up is to rotate each student through various jobs, such as shop superintendent, foreman, assistant foreman, machine operator, stock man, and laborer.
For effective checking and ease in issuing tools, the open panel type of tool arrangement is recommended. Whether the tools are locked up by folding the panel, or whether a large counterweighted door pulls down to enclose the tools is unimportant. However, there should be a means of securing the tools between classes and at the end of the day. Tools should be checked by the teacher at the beginning and at the end of each period, and during the class the equipment is to be issued only by the paper slip method. Any tool that is lost during the period and not returned within a certain length of time would be paid for by the whole group, including the instructor. The tool room boy on duty the day the object was lost would be in charge of buying a new tool at school discount and then assessing the whole group their share of the cost.

**Operations to Be Experienced**

Of the great number of operations which could be presented to a high school group, the following are likely to offer the most valuable experience:

1. To set up and care for an oxyacetylene welding outfit with regard for safety precautions.

2. To weld and braze steel with the oxyacetylene flame.
3. To cut ferrous metals with the oxyacetylene flame.
4. To weld and braze cast iron with the oxyacetylene flame.
5. To weld and braze aluminum with the oxyacetylene flame.
6. To weld brass with the oxyacetylene flame.
7. To silver solder brass and copper with the oxyacetylene flame.
8. To weld sheet metals with the oxyacetylene flame.
9. To weld steel with the electric arc.
10. To soft solder tin, galvanized iron, brass and copper.
11. To weld and bend pipe.
12. To weld, bend, and cut structural steel.
13. To hard surface steel.
14. To weld fenders.
15. To weld and build up chain links.
16. To build up shafts.
17. To test welds according to American Welding Society Standards.
18. To preheat castings.
19. To braze or weld auto blocks and heads.
20. To harden steel with the oxyacetylene flame.
21. To temper steel with the oxyacetylene flame.
22. To anneal steel with the oxyacetylene flame.
23. To case harden steel with the oxyacetylene flame.
24. To anneal copper and brass with the oxyacetylene flame.
25. To anneal aluminum with the oxyacetylene flame.

26. To get up heat in a blacksmith's forge.

27. To forge iron and steel.

28. To forge a scroll.

29. To forge and heat treat tool steel.

30. To analyze repairs and select the correct procedure of welding automobiles.

31. To analyze repairs and select the correct procedure of welding simple farm equipment.

32. To lay out and construct simple jobs in an efficient manner.

**Visual Aids**

Without a complete selection of visual aids, well constructed and arranged before attempting to offer this course, it is not recommended that the program be offered. Unless the teacher and the shop are properly prepared in advance, the instruction will not be worthwhile. The following visual aids must be carefully worked out prior to the conducting of this class:

1. **Instruction sheets:** An ample supply should be mimeographed on 8½ x 11 paper, and the stencils carefully stored.
   a. Information
   b. Operation
   c. Job
   d. Assignment
2. **Motion pictures:** Order in advance.

a. U.S. Office of Education
   1) "Brazing Flanges with Silver Solder"
   2) "Hand Soldering"
   3) "The Guided Bend Test"
   4) "Oxyacetylene Welding. Light Metal"

b. U.S. Bureau of Mines
   1) "Tin from Bolivia"
   2) "Magnesium--Metal from the Sea"
   3) "Aluminum, Mine to Metal"
   4) "How to Form Aluminum"
   5) "Nickle Mining"
   6) "Nickle Refining"
   7) "Stainless Steel"
   8) "Copper Mining"
   9) "Copper Refining"

c. U.S. Steel Corporation of Delaware
   1) "Making and Shaping Steel"
   2) "Steel, Man's Servant"

d. Linde Air Products Company
   1) "Modern Metalworking with the Oxyacetylene Flame"
   2) "Oxyacetylene Welding in Industrial Production"
   3) "Unionmelt Welding in Industry"
   4) "Unionmelt Welding in Industry--General Applications"
   5) "Unionmelt Welding--An Electric Welding Process"

e. General Electric Company
   1) "Inside of Arc Welding"
   2) "Story of A. C. Welding"

f. Lincoln Electric Company
   1) "Story of Arc Welding"

g. Harnischfeger Corporation
   1) "New Horizons in Welding"

h. Aluminum Corporation of America
   1) "How to Weld Aluminum"

i. Jam Handy
   1) "Introduction to Oxyacetylene Welding"
j. Bell and Howell
   1) "Furnaces of Industry"

k. American Iron and Steel Institute
   1) "Steel--A Symphony of Industry"

3. Cross section equipment
   a. Regulators (Obtain seconds from manufacturers)
   b. Cylinder valves (Obtain seconds)
   c. Cylinders
   d. Torches

4. Metals
   a. Sheet samples, properties
   b. Identification chart
   c. Rod and electrode samples
   d. Finish samples
   e. Grades of polishes
   f. Oxide color chart

5. Proper use of hand tools--charts
   a. Hacksaw, Diston Saw Company
   b. Files, Diston Saw Company
   c. Instruments for measuring, L. S. Starrett Company
   d. Drills, Cleveland Drill Company
   e. Hand tools, General Motors
   f. Hand tools, Stanley Tool Company

6. Instructional wall charts
   a. Victor Equipment Company
      1) Regulators
      2) Torches
      3) Setting up oxyacetylene equipment
      4) Cylinder valves
   b. Lincoln Electric Company
      1) Electrodes
      2) Arc welded design
      3) Arc welding inspection
   c. Aluminum Corporation of America
      1) Welding and brazing aluminum
      2) Production of aluminum
d. Linde Air Products Company
   1) Safety

e. Harnischfeger Corporation
   1) Rod chart

Books

Of the large amount of material published on the subject of welding, the following publications are suggested as most helpful to the instructor of industrial arts:

1. References


2. Textbooks


Several of the leading manufacturers of welding equipment and supplies have prepared some very helpful publications. The following concerns will provide books and pamphlets:

3. Manufacturers' publications
a. Lincoln Electric Co., Cleveland, Ohio
b. Air Reduction Co., 60 East 42nd Street, New York, N. Y.
c. Linde Air Products Co., 30 East 42nd Street, New York, N. Y.
e. Hobart Bros. Co., Box UE32, Troy, Ohio
g. Aluminum Corporation of America, Pittsburgh, Pennsylvania.
MANIPULATIVE AND STUDY LESSONS

Introduction

The following information is an outline of units of study which is suggestive of the type of material to be included in the shop instruction sheets. No attempt has been made in this report to prepare complete lesson plans. Shop instructors must formulate instructional materials to fit their shops, since two school shops are seldom identical. Likewise, shop teachers vary in choice of subject matter. Of course, the teacher will wish to add to each information sheet page references to current texts in the shop library, and questions designed to test student comprehension of subject matter.

From the material outlined here many instruction sheets have been made up, illustrated, and tested. The results obtained in every case were satisfactory.
HISTORY OF WELDING

Information Sheet

Objective: To present a brief historical background and chronological development of oxyacetylene welding.

1862: Calcium carbide discovered by Woehler, Germany.
1891-92: Commercial process for producing calcium carbide in an electric furnace was simultaneously discovered in Paris, France, by Moissan, and in Spray, North Carolina, by Willson.
1895: Oxyacetylene flame discovered by Le Chatelier of France.
        First calcium carbide factory operated by Willson at Spray, North Carolina.
        Successful operation of first liquid air machine at Niagara Falls, New York, at Froges, France, and Foyers, Scotland.
1897: Method of dissolving acetylene in acetone, allowing economical storage and shipping, was discovered by Claude and Hess.
1900: Workable oxyacetylene torch devised by Fouche and Picard of Paris, France.
1901: First patent in oxygen cutting process taken out by Herman A. E. Menne of Germany.
1902: Oxygen produced commercially.
1903: First oxyacetylene torches commercially produced by Fouche and Picard of Paris, France.
1904: Oxyacetylene cutting process first used in U. S. by John Harris, Cleveland.
1905: First commercial oxyacetylene cutting done by Felix Jottrand, U. S. A.

1906: First United States patent of the oxyacetylene cutting process by Felix Jottrand.

1907: First factory operated on large scale to produce oxygen by the liquid air process by Linde Air Products Co., New York.

1914: Oxyacetylene cutting under water introduced in France and Germany.

1914-18: World War production of depth bombs, poison gas tanks, torpedo casings, etc., accelerated progress of the industry and improved its techniques.

1922: Method of cutting cast iron with the oxyacetylene flame introduced by the Oxweld Acetylene Co., New York. First oxyacetylene-welded pressure pipe line laid for the Butte Water Co., Butte, Montana.

1925: Hard surfacing process introduced.

1927: One story all-welded steel building covering a two acre area was completed by the Jones and McLaughlin Steel Corporation, New York.
Information Sheet

Objective: To encourage additional reading and thought to improve knowledge of materials used in welding.

1. Manufacture
   a. Liquification
   b. Electrolysis of water
   c. First commercial plant, 1903

2. Storage
   a. Seamless cylinders, 100 and 220 cubic ft.
   b. High pressure: 2000 lbs. per sq. inch
   c. Standard color: green
   d. Dangerous in fire
   e. Cylinder valve double seating
   f. Bursting disc

---

### 220-cubic-foot Oxygen Cylinder

- **Tobin Bronze Valve**
- **Removable Metal Cap**
- **Safety Fuse Plug and Disk**
- **Pressed Steel Neck Ring**

**Oxygen Capacity of Cylinder**
- 220 cu. ft.
- At 2000 lb. per sq. in.
- Pressure at 70°F
- Water Capacity: Approximately 2650 cu. in.

**Dimensions**
- 8.5" I.D., 31"
- Min. Wall: .260"
4. **Properties**
   a. Odorless, tasteless
   b. Will not burn
   c. Supports combustion
   d. Spontaneous combustion when in contact with oil
   e. Affinity for metals causes oxides to be formed
   f. At 70°F., 12.08 cubic ft. weigh 1 lb.
   g. Used in respiration

5. **Manifold system**
   a. More shop floor space
   b. Extra heavy copper tubing
   c. Wrought iron pipe around shop
   d. High pressure valves and fittings
   e. Bursting discs
   f. Moisture trap

6. **Commercial producers**
   a. Linde Air Products Co.
   b. Air Reduction Sales Co.
   c. National Cylinder Gas Co.
**ACETYLENE**

**Information Sheet**

**Objective:** To encourage additional reading and thought to improve knowledge of materials used in welding.

1. **Manufacture**
   a. Source: calcium carbide
   b. Formula
   c. Reaction
   d. First produced in 1336

2. **Storage**
   a. Welded cylinders
   b. 250 lbs. per sq. inch and 250 cubic ft.
   c. Wrench type valve
   d. Fusible plugs
   e. Porous filler: charcoal, infusorial, earth, asbestos, portland cement
   f. Acetone absorbs gas
   g. Dangerous to compress in free state over 15 lbs. per sq. inch
   h. Do not drop cylinders

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[Diagram of Acetylene Cylinder]

ACETYLENE CAPACITY APPROX. 275 CU. FT. AT 250 LB. PER SQ. IN. PRESSURE AND 70° F. WATER CAPACITY APPROXIMATELY 4021 CU. IN.

MIXTURE OF BALSAM WOOD AND INFUSORIAL EARTH

FINE ASBESTOS

SAFETY FUSE PLUGS

LONG FIBRE ASBESTOS

SAFETY FUSE PLUG

ACETYLENE CLOTH

STEEL VALVE

REMOVABLE METAL CAP

2.5"
3. **Calcium carbide**
   a. Calcium: 62.5% from limestone
   b. Carbon: 37.5% from coal
   c. Will not burn
   d. Cannot explode
   e. Kept in air tight can

4. **Generators**
   a. Water to carbide
   b. Carbide to water
   c. Portable
   d. Approved by Underwriters' Laboratories
   e. Low pressure: 1 lb.
   f. Medium pressure: 12 lbs.

5. **Manifolds**
   a. Extra heavy brass tubing
   b. High pressure fittings and valves
   c. Wrought iron pipe
   d. Moisture trap
   e. Flash arrester
   f. Blow off exhaust through roof

6. **Uses**
   a. Welding
   b. Lighting

7. **Properties**
   a. 93% carbon and 7% hydrogen
   b. Endothermic: absorbs heat during formation
      (Exothermic: generates heat during formation)
   c. 14.55 cubic feet equal 1 lb. at 70° F.
   d. Burns with black smoke
   e. When mixed with oxygen produces 6300° F.

8. **Commercial producers**
   a. Linde Air Products Co.
   b. Air Reduction Sales Co.
   c. National Cylinder Gas Co.
**REGULATORS**

**Information Sheet**

**Objective:** To acquaint students with basic tools of industry, and to point out how this equipment can be used to their personal advantage.

1. **Uses**
   a. Reduce cylinder pressure
   b. Safety device
   c. Welding and cutting
   d. Spray painting

2. **Types**
   a. Two stage reduction for high pressures
   b. Single stage reduction for moderate pressures
   c. High pressure regulator
   d. Large capacity regulator
   e. Manifold regulators
   f. Air, oxygen, hydrogen, or acetylene

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**Figure 37 - Two-stage Regulator**
3. Oxygen
   a. Cylinder gauge
      1) 0 to 3000 lbs. per square inch graduations
      2) 0 to 220 cubic ft.
   b. Hose pressure gauge
      1) 0 to 50 lbs. for welding
      2) 0 to 150 lbs. for cutting
   c. Bourdon tube
   d. Diaphragm
   e. Adjusting spring
   f. Nozzle
   g. Green and right hand threads on fittings

4. Acetylene
   a. Cylinder gauge
      1) 0 to 500 lbs. per sq. inch
      2) 0 to 15 cubic ft.
   b. Hose pressure gauge
      1) 0 to 30 for welding
      2) Same for all operations
   c. Bourdon tube
   d. Diaphragm
   e. Adjusting spring
   f. Nozzle
   g. Red and left hand threads on fittings
CUTTING AND WELDING TORCHES

Information Sheet

Objective: To acquaint students with basic tools of industry, and to point out how this equipment can be used to their personal advantage.

1. Welding torches
   a. Low pressure oxyacetylene or injector type
      1) Low acetylene line pressure
      2) High oxygen
      3) Commonly used off generators

   b. Oxyhydrogen
      1) Used on thin metals
      2) Equal pressure
      3) More expensive than acetylene
c. Equal pressure oxyacetylene
   1) Most common
   2) Equal line pressures

   Equal Pressure Type General Purpose Welding Torch

   d. Atomic hydrogen
      1) Two tungsten electrodes
      2) AC current
      3) Stream of hydrogen gas surrounds weld
      4) For stainless steel and thin metal

   e. Heliarc
      1) One tungsten electrode
      2) Water cooled
      3) Inert gas shields weld
      4) New development for aluminum, magnesium, and other hard-to-weld metals

   f. Metallic electrode arc
      1) AC or DC current
      2) Parent metal grounded
      3) Used under water
      4) Commonly used in industry on steel and occasionally on castings
      5) Filler added through arc stream
g. Carbon electrode
1) AC or DC
2) Filler rod added separately
3) Occasionally used on special alloys

h. Natural gas and air
1) For preheating
2) For hard soldering
3) For soft flame soldering

2. Cutting torches
a. Oxyacetylene cutting torch
1) Preheating flame adjustment
2) Oxygen cutting valve
3) Plain tip
4) Grooving tip
5) Cutting holes
6) Commonly used in industry in heavy steel work

b. Oxyacetylene cutting attachment
1) Fits torch handle of same brand
2) Preheating flame adjustment
3) Oxygen cutting valve on attachment
4) Plain tip
5) Grooving tip
6) Commonly used in all shops for steel

Cutting Attachment for a Welding Torch
c. Commercial gas cutting torch
   1) Similar to oxyacetylene cutting torch
   2) Cheaper
   3) Gas can only be used for cutting
   4) Used in wrecking yards for steel

d. Oxy-electric arc torch
   1) Metallic electrode tube
   2) Oxygen line and cutting valve
   3) New development for stainless steel and cast iron

e. Underwater oxy-hydrogen torch
   1) Similar to oxyacetylene cutting torch
   2) Air line and bubble tip
   3) Hydrogen for deep water work
   4) Acetylene safe to use in shallow water
   5) Light above water with lighter, or under water with electric spark
   6) Extensively used in navy, ship repair, and bridge construction

f. Underwater oxy-arc cutting
   1) Insulated tubular rod
   2) Oxygen line and cutting valve
   3) D. C. current 300 amperes
   4) Double current control
   5) Work grounded
   6) Developed in 1942
   7) Now more commonly used than oxy-hydrogen

g. Oxygen lance
   1) Long tube
   2) High pressure oxygen line and valve
   3) Used only in industry to cut large pieces
      a) Trim ingots
      b) Trim risers
      c) Assist cutting torches

h. Manufacturers
   1) Victor Equipment Co.
   2) Linde Air Products Co.
   3) Smith Welding Co.
   4) Lincoln Electric Co.
   5) General Electric Co.
SETTING UP THE OXYACETYLENE EQUIPMENT
TO WELD STEEL

Job Sheet

Objective: To acquaint students with the basic tools of industry, and to point out how this equipment can be used to their personal advantage.

Equipment:

- 1 oxygen cylinder
- 1 oxygen regulator
- 1 oxygen hose
- 1 acetylene cylinder
- 1 acetylene regulator
- 1 acetylene hose
- 1 welding torch with tips
- 1 spark lighter
- 2 pieces of steel 1/8" x 1" x 4"
- 2 fire bricks
- 1 welding bench
- 1 welding helmet

Procedure:

1. **Mount cylinders**
   a. Acetylene cylinder to left
   b. Chain or clamp to wall or truck

2. **Remove caps**
   a. Secure caps to or near cylinders
   b. Remove cylinder valve outlet caps

3. **Attach regulators**
   a. Open each valve slightly to clean passage, then close
   b. Screw on regulators and tighten securely with wrench
   c. Test joints and cylinder valve packing with soap and water
   d. Standing behind the cylinder valve outlet, slowly open each valve
   e. Screw in the adjusting screws and blow out regulators
4. **Connect hoses**
   a. Left hand threads on acetylene at regulator
   b. Right hand threads on oxygen at regulator
   c. Blow out hoses, then connect torch

5. **Adjust working pressures**
   a. Determine the thickness of the metal to be welded.
      It is 1/8" steel.
   b. Determine from the wall chart the size tip to use
   c. The same chart gives the working pressures.
      They are 2 lbs. oxygen and 2 lbs. acetylene.
   d. Turn adjusting screws to proper flowing pressures

6. **Light the torch**
   a. Spark lighter in left hand and torch acetylene valve between thumb and forefinger of right hand.
   b. While holding the torch over the welding bench, open the acetylene valve slightly and light the escaping gas with the spark lighter.
   c. Quickly, to avoid black smoke, open the acetylene torch valve until the flame just begins to jump away from the tip.
   d. Adjust to a neutral flame by opening the oxygen torch valve until the sharp tip leaves the inner cone.

7. **Weld metal**
   a. Place the two pieces of metal over air between two firebricks with 1/16" space between pieces and arrange so the joint is parallel to the front of the bench.
   b. Apply heat to right hand corners of two pieces of metal in such a manner as to cause the two pieces to melt simultaneously and flow together.
   c. Add filler rod to the puddle formed.
   d. Continue to form small pools of molten metal, and stick rod into the puddle.
   e. Should the pieces tend to separate by expansion, tack the left hand end.
ACETYLENE OR \( C_2H_2 \)
14.5 cu. ft. weighs 1 lb. at 70°F or room temp
Made from carbide and water
\( CaC_2 + 2H_2O \rightarrow C_2H_2 + Ca(OH)_2 \)

OXYGEN OR \( O_2 \)
12.08 cu. ft. weighs 1 lb. at 70°F or room temp
Made by liquefaction of air
Air (285°F below zero) \( \rightarrow O_2 + N_2 \)
Objective: To acquaint students with the refining and processing of iron, the most important industrial material.

1. **Refining ore in the blast furnace**

Coke, ore and limestone are added at intervals.

- **COKE, ORE AND LIMESTONE**
- **ADDED AT INTERVALS**
- **DOUBLE BELL APPARATUS FOR ADMITTING NEW MATERIAL**
- **GAS OFFTAKE**
- **COKE, ORE AND LIMESTONE IN ALTERNATE LAYERS, SETTLE AS IRON IS FORMED AT BOTTOM**
- **BUSTLE PIPE AROUND FURNACE**
- **TUVERES**
- **COMPRRESSED AIR**
- **SLAG TAP HOLE**
- **FIRE BRICK**
- **IRON TAP HOLE TO STEEL AND CASTING PROCESSES OR TO PIGS**

Coke is ignited at bottom and burns under forced draft. As it burns away, ore and limestone are converted to liquid iron and slag. All materials move downward by gravity and stock is kept filled by fresh charges admitted through bells. Slag and iron are tapped off at intervals as they accumulate. 60 tons of metal at each tap or 750 tons a day is average blast furnace output.

The Blast Furnace
2. **Processing pig iron, the product of the blast furnace**

Blast furnace product is cast into pigs or used in the molten state, depending on subsequent processing. Iron from blast furnace is modified by additions of scrap metal, ferro alloys, etc., to make a metal more suitable for use in the various cast iron, wrought iron and steel-making processes. Modification may also be carried on during the latter processes or after their completion.

- **Blast Furnace**
  - Remelting Furnace
    - White Cast Iron Castings
    - Heat Treating Oven
    - Malleable Castings
    - Gray Cast Iron Castings

- **Puddling Furnace**
  - Reheat & Quench Process
  - Cast Iron, Wrought Iron and Steel are subjected to various processes such as machining, rolling, etc., in order to obtain metals in forms, plates and shapes suitable for use in fabrication and assembly.

- **Steel Castings**
  - Ingots
    - Blooms
      - Billets
        - Bars
          - Steel
            - Skelp
              - Pipe

- **Tool Skelp**
  - Sheet Bars
    - Plates
      - Black Sheets
        - Tin Sheets
          - Galvanized Sheets
            - Terne Sheets
              - Wire

- **Sheet Skelp**
  - Sheets
    - Rivets
      - Rods
        - Small Shapes
          - Rods

- **Structural Shapes**
  - Rails
    - Structure
      - Steel
        - Bars
          - Shapes

- **Rolls**
  - Nails
    - Cables
      - Fencing
Objective: To encourage the use of knowledge gained in academic classes to solve certain shop problems.

1. How many cubic feet of oxygen are there in one large cylinder when charged to 2000 lbs. per square inch?
2. Figuring oxygen at 2 cents per cubic foot, what is the cost of 2 cylinders?
3. The cost of acetylene is 3½ cents per cubic foot. What does a full cylinder cost?
4. Use the chart for this question. A man using a No. 2 tip with 2 lbs. of oxygen and 2 lbs. of acetylene welds for 1 hour. How much oxygen does he use? How much acetylene?
5. Use the chart. Approximately what length of time and how much oxygen would it take to weld 5½ feet of 1/8" steel?
**PHYSICS AND CHEMISTRY OF WELDING**

**Information Sheet**

**Objective:** To encourage the correlation of academic subjects and shop work for better understanding of basic science.

1. **Measurement of heat**
   a. Degrees Fahrenheit and centigrade
   b. Pyrometer
   c. Thermocouple
   d. Oxide heat colors
   e. Metal colors

2. **Transmission of heat**
   a. Conduction
   b. Convection
   c. Radiation

3. **Effects of heat on metals**
   a. Expansion and contraction
   b. Stress and strain
   c. Fusion
   d. Adhesion
   e. Cohesion
   f. Melting point
   g. Vaporization
      1) Poisonous
      2) Explosive

4. **Oxidation**
   a. Rapid
   b. Flash points
   c. Spontaneous combustion
   d. Cutting metals
   e. Rust
   f. Extinguishing
      1) Pyrene
      2) Fog
      3) \( \text{CO}_2 \)
      4) Water
5. **Light**  
   a. Heated metals  
   b. Flames  
   c. Infra-red  
   d. Ultra-violet  

6. **Sound**  
   a. Identify hard steel  
   b. Arc sound  
   c. Identify sheet metals  
   d. Test for fractures  

7. **Chemical reactions**  
   a. Production of oxygen  
   b. Production of acetylene  
   c. Production of steel  
   d. Production of aluminum  
   e. Production of copper  

8. **Properties of metal elements**  
   a. Iron  
   b. Copper  
   c. Tin  
   d. Aluminum  
   e. Silver  
   f. Zinc  

9. **Effect of elements on alloys**  
   a. Fluxes  
   b. Rod castings  
   c. Burn ointments  
   d. Crucibles  
   e. Furnace linings  
   f. Pickling solutions  
   g. Etching solutions  
   h. Electroplating solutions
Objective: To acquaint the students with some of the industrial names for welds in various positions.

JOINT POSITIONS
Terminology

Information Sheet

Objective: To acquaint the students with the definitions and purposes of many of the industrial terms and processes pertaining to welding.

Definitions of Welding Terms and Processes

1. Acetone: An inflammable and very volatile liquid used in acetylene cylinders to dissolve and stabilize acetylene gas under high pressure.

2. Acetylene: A highly combustible gas composed of carbon and hydrogen \((\text{C}_2\text{H}_2)\) and used as a fuel gas in oxyacetylene welding.

3. Adhesion: A condition existing in a welded joint when the molten metal merely sticks to the adjacent metal without actually being fused with it.

4. Air-Acetylene Welding: A gas welding process in which the welding heat is obtained from the burning of acetylene and air.

5. Alignment: The arrangement of parts in a straight line or proper position in relation to each other to restore the original shape as nearly as possible.

6. Alloy: A mixture of two or more entirely different metals intimately united by melting them together.

7. Alternating-Current Arc Welding: An arc welding process in which the power supply at the arc is alternating current.

8. Arc Brazing: An electric brazing process in which the heat is obtained from an electric arc, formed between the base metal and an electrode or between two electrodes.

9. Arc Voltage: The voltage across the arc.
10. ARC WELDING: A nonpressure (fusion) welding process in which the welding heat is obtained from an arc either between the base metal and an electrode or between 2 electrodes.

11. ASBESTOS: A fibrous material refractory to heat, used in welding as insulation against transmission of heat from one body of metal to another.

12. ATOMIC HYDROGEN WELDING: An alternating-current arc welding process in which the welding heat is obtained from an arc between two tungsten electrodes in an atmosphere of hydrogen.

13. AUTOGENOUS WELDING: The process of joining two or more pieces of metal by fusing, without additional metal being added, and without the aid of hammering or pressure.

14. BACKFIRE: The popping out of the torch flame or momentary burning of the gases within the torch tip.

15. BACKHAND WELDING: A method of gas welding in which the flame is directed toward the finished weld.

16. BACKING STRIP: Material (metal, asbestos, carbon, etc.) used to back up the root of the weld and retain the molten metal.

17. BACK-STEP WELDING: A welding technique in which the beads of weld metal are deposited opposite to the direction of progress of the weld along the joint.

18. BARE, LIGHTLY COATED ELECTRODE: A solid metal electrode, with no coating other than that necessary to manufacture the electrode, or with a light coating.

19. BASE METAL (PARENT METAL): The metal to be welded or cut.

20. BEAD WELD: A type of weld made by one passage of the electrode or rod.

21. BEVELLING: The cutting or forming of angles on the edges or end of metal plates, shapes, or sections.

22. BLOWHOLE: A hole or cavity formed in the weld by entrapped gases, dirt, grease, or other foreign matter. Usually caused by welding too fast.
23. **BOND**: The junction of the weld metal and the base metal.

24. **BOURDON TUBE**: A curved metal elastic tube, oval in cross section, open at one end to gas, steam, or other fluid pressure and closed at the other. Changes in pressure cause it to move, and this movement is used to indicate the pressure.

25. **BRAZING**: A group of joining processes in which the filler metal is a nonferrous metal or alloy whose melting point is higher than 1,000 °F but is lower than that of the metals or alloys to be joined. The application of brasses or bronzes on steel, cast iron, or malleable iron is an example of the brazing process.

26. **BRONZE WELDING**: A brazing process in which the filler metal is a bronze rod which is used in the same manner and on the same joint design as would be used if a fusion weld were being made.

27. **BUCKLING**: Distortion of sheet or plate, due to the forces of expansion and contraction caused by the application of heat or excessive loading.

28. **BUTT WELD**: A weld made between the ends or edges of two plates or surfaces approximately in the same plane with each other.

29. **CAPILLARY ATTRACTION**: The action by which the surface of a liquid where it is in contact with a solid (as in a capillary tube) is elevated or depressed.

30. **CARBON ARC CUTTING**: The process of cutting or severing metals by melting with the heat of the carbon arc.

31. **CARBON ARC WELDING**: An arc welding process in which a carbon or graphite electrode or electrodes are used, with or without filler metal.

32. **CARBON DIOXIDE**: A heavy, colorless gas (CO₂) composed of carbon and oxygen, which has the property of extinguishing flame. It is present in the gases given off by an oxyacetylene welding flame.

33. **CARBURIZING (CARBONIZING) FLAME**: A gas flame having the property of introducing carbon into the metal heated.
34. **CAST-IRON THERMIT**: A thermit mixture containing additions of ferro-silicon and mild steel.

35. **COLD SHUT**: Poor fusion between the layers of weld metal or between the weld metal and the base metal.

36. **COMBUSTION**: The process of rapid oxidation or burning.

37. **CONCURRENT HEATING**: Supplementary heating applied to a structure during the course of welding.

38. **CONDUCTIVITY**: The rate at which a metal body will transmit electrical current or heat through its mass.

39. **CONE**: The part of the welding flame that is conical in shape and located at the end of the welding tip.

40. **CONTRACTION**: The shrinkage of metal due to cooling from an elevated temperature.

41. **COVERED (SHIELDED-ARC) ELECTRODE**: A metal electrode which has a relatively thick covering material serving the dual purpose of stabilizing the arc and improving the properties of the weld metal.

42. **COVER GLASS**: A clear glass used to protect the lens in goggles, face shields, and helmets from spattering material.

43. **CRATER**: A depression in the deposited weld metal at the end of an arc weld.

44. **CURRENT DENSITY**: Amperes per square inch of surface.

45. **CUTTING PROCESS**: The process of severing or cutting metals by means of oxidation or melting. Oxygen cutting is an oxidation process of cutting. Metal-arc and carbon-arc cutting are melting processes.

46. **CUTTING TIP**: A gas torch tip especially designed for oxygen cutting.

47. **CUTTING TORCH OR BLOWPIPE**: An apparatus used in oxygen cutting. It is designed to control the gases used for preheating as well as the oxygen used for cutting.

48. **CYLINDER**: A portable container used for storage of compressed gas.
49. **DEPOSITED METAL:** Metal that has been added to a weld from an electrode or welding rod by a welding process.

50. **DIAPHRAGM:** A thin, flexible partition.

51. **DIES:** A pair of cutting or shaping tools, which, when moved toward each other, shape an object or surface between them by pressure or by a blow.

52. **DIP BRAZING:** A group of brazing processes in which the heat is obtained from a bath of molten metal or chemical. The filler metal may or may not be obtained from the bath.

53. **DIRECT-CURRENT ARC WELDING:** An arc welding process in which the power supply at the arc is direct current.

54. **DRAG:** In oxyacetylene cutting, the amount by which the point where the oxygen jet leaves the kerf departs from the perpendicular through the point at which the jet enters the kerf, often expressed as a percentage of the plate thickness.

55. **DUCTILITY:** The property which permits a metal to be drawn, formed, or shaped.

56. **EDGE WELD:** The joining of two or more parallel pieces of metal by welding their edges together.

57. **ELASTIC LIMIT:** The maximum load that a metal will sustain before it takes a permanent set.

58. **ELECTRIC BRAZING:** A group of brazing processes in which the heat is obtained from electric current.

59. **ELECTRODE:**

   **ATOMIC HYDROGEN WELDING:** One of two tungsten rods through which current is conducted between the electrode holder and the arc.

   **CARBON ARC WELDING:** A carbon or graphite rod through which current is conducted between the electrode holder and the arc.

   **METAL ARC WELDING:** Filler metal in the form of a wire or rod, either bare or covered, through which current is conducted between the electrode holder and the arc.

   **RESISTANCE WELDING:** A bar, wheel, or die through which the current is conducted and the pressure applied to the work.
60. **ELECTRODE HOLDER:** A device used for mechanically holding the electrode.

61. **ELONGATION:** The amount that a metal will stretch before it is pulled apart.

62. **FILLER ROD:** A rod or wire used to supply additional metal to a weld.

63. **FILLET WELD:** A weld made in a corner, as in a lap or T-joint.

64. **FILTER LENS:** A colored glass used in goggles, helmets, and shields to exclude harmful light rays.

65. **FLAME BORING:** A flame machining process which combines flame drilling with flame turning to produce a round hole in the surface of a piece. This process is used to remove metal from the ends of steel billets in preparation for centering or piercing operations.

66. **FLAME CLEANING:** A process of dehydrating and removing scale and foreign matter from surfaces preparatory to painting, by passing oxyacetylene flames rapidly over the surface.

67. **FLAME DRILLING:** A flame machining process in which to drill or punch holes in metal, a flame machining tip or oxygen lance is moved axially (in the same direction as that of the stream of oxygen from the tip). The process also serves to remove countersunk rivets or long bolts frozen in place without scoring the sidewalls of the hole.

68. **FLAME GROOVING:** A flame machining process in which a hand- or machine-guided torch is used to produce U-shaped grooves in steel surfaces. This process will remove rivet heads, defective welds, and surface defects, will cut fillets, and will prepare plate edges for welding. The deep narrow grooves produced by this process can be easily welded where this is required.

69. **FLAME MACHINING PROCESS:** The process of controlled removal of metal by surface oxidation to develop a desired surface contour. It differs from oxygen cutting in that it is not used to cut or sever pieces of metal but to process or shape metal surfaces. In some cases, flame machining is combined with flame cutting operations to develop a desired surface contour or shape.
70. **FLAME MACHINING TIP**: A gas torch tip especially designed for flame machining.

71. **FLAME PLANING**: A flame machining process used to remove surface defects from steel plates, billets, and other steel sections by means of wide and relatively shallow surface cuts. The flame-planed surface is either machined further or hot-rolled to the desired finished dimensions.

72. **FLASHBACK**: The disappearance of the flame from the end of the welding tip into or back of the mixing chamber of the torch. This differs from a backfire in that the flame continues to burn inside the torch without popping back out to the end of the tip, and the burning is generally accompanied by a squealing noise.

73. **FLASH-BUTT WELDING**: A resistance butt-welding process in which the potential (voltage) and current are applied before the parts to be welded are brought in contact. The heat for welding is obtained mainly from a series of arcs between the parts to be welded. The parts are pushed or drawn together when the welding temperature is reached.

74. **FLAT POSITION WELDING (DOWNHAND)**: A welding position in which the plates to be welded are in the horizontal plane and the weld is made on the top side of the plates.

75. **FLUX**: A chemical powder or paste used to dissolve oxides, clean the metal of undesirable inclusions, and prevent oxidation of the molten metal during welding or brazing operations.

76. **FOREHAND WELDING**: A method of gas welding in which the flame is directed toward the base metal ahead of the finished weld.

77. **FORGE WELDING (BLACKSMITH, ROLL, HAMMER)**: A group of pressure welding processes in which the parts to be welded are brought to a suitable temperature by means of external heating and the weld is made by pressure or blows.

78. **FREEHAND FLAME CUTTING**: A cutting process in which the operator both holds and guides the hand cutting torch.
79. FREEHAND GUIDED FLAME CUTTING: A cutting process in which the operator holds the torch while guiding it along the line of cut by some mechanical means. These guides may be a straight edge or bar for cutting straight lines, a radius rod with pivot for cutting circles, or roller attachments for cutting plate with irregular surfaces. Bevel cuts can be made with any of the above attachments or guides.

80. FURNACE BRAZING: A brazing process which obtains its heat from a suitable furnace. The parts to be joined are assembled with filler metal and flux in place and require only the furnace heat at brazing temperature to complete the joint.

81. FUSION WELDING: A group of processes in which the metals are welded together by bringing them to the molten state at the surfaces to be joined without the application of mechanical pressure or blows. Filler rod may or may not be used, depending upon the joint design and the thickness of the parts to be welded.

82. GAS BRAZING: A brazing process in which the heat is obtained from a gas flame.

83. GAS CUTTING (OXYGEN CUTTING): The process of severing or cutting ferrous metals by means of chemical action on elements in the base metal.

84. GAS WELDING: A nonpressure (fusion) welding process in which the welding heat is obtained from a gas flame.

85. GUIDED BEND TEST: A bending test in which the test piece is bent to a definite shape by means of a jig.

86. HAND (FACE) SHIELD: A protective device used in arc welding for shielding the face and neck, equipped with suitable filter glass lenses and designed to be held by hand.

87. HARDENING: The process of increasing the hardness of metals by heat treatment, cold working, or the addition of alloying elements.

88. HARD SURFACING (HARD FACING): The process of applying extremely hard alloys to the surface of a softer metal in order to increase its resistance to wear, abrasion, corrosion, or impact.
89. **HEAT-AFFECTED ZONE:** The portion of the base metal whose structure or properties have been changed by the heat of welding or cutting.

90. **HELMET SHIELD:** A protective device used in arc welding for shielding the face and neck, equipped with suitable filter glass lens and designed to be worn on the head.

91. **HORIZONTAL POSITION OF WELDING:** A welding position in which the plates to be welded are in the vertical plane and the welded joint is in the horizontal plane.

92. **INDUCTION BRAZING:** An electric brazing process in which the heat is obtained from the resistance to the flow of an electric current.

93. **INFRARED:** Light rays that are outside of the red end of the visible spectrum. These rays are given off by the arc of an electric arc welding process and by the oxyacetylene flame.

94. **INTERMITTENT WELD:** A weld which is not continuous but is broken by unwelded spaces in the joint.

95. **KERF:** The space from which the metal has been removed by a cutting process.

96. **LANCE:** A long steel pipe, usually 1/4 inch or 3/8 inch normal pipe size, used to direct a stream of oxygen against a heated surface to cut or pierce heavy steel sections.

97. **LAP JOINT:** A type of joint formed by two overlapping plates with the edge of each plate welded to the face of the other.

98. **LAYER:** A quantity of filler metal deposited in a joint to cover completely the filler metal previously deposited. A welded joint on heavier plate may require several layers of weld metal to weld the plate completely.

99. **LEAD WELDING (LEAD BURNING):** A welding process in which both the base metal and the filler metal are lead.
100. **MACHINE FLAME CUTTING:** A flame cutting process in which the speed, angle, and direction of the cutting torch is controlled by a motor-driven variable-speed machine.

101. **MANIFOLD:** A header with outlets or branches to which several cylinders of gas may be connected to supply gas to a number of outlets or stations.

102. **MANUAL WELD:** A weld in which the arc or the torch motion is controlled by the hand.

103. **MELTING POINT:** The temperature at which a metal changes from the solid to the liquid form.

104. **METAL ARC BRAZING:** An electric arc brazing process in which bronze, brass, or other copper alloy electrodes supply the filler metal.

105. **METAL ARC CUTTING:** The process of severing or cutting metals with the heat of the metal arc. Non-ferrous metals can be cut by this process.

106. **METAL ARC WELDING:** An arc welding process in which the electrode supplies the filler metal in the weld.

107. **MIXING CHAMBER:** That part of a gas welding or cutting torch in which the gases are mixed for combustion.

108. **NEUTRAL FLAME:** A gas welding flame in which the inner cone or that portion of the flame used is neither oxidizing nor carburizing.

109. **NITRIDE:** A compound of nitrogen with another element, as boron, silicon, and many metals, injurious to metal.

110. **NON-FERROUS:** Metals containing no ferrite or iron. Copper, brass, bronze, aluminum, and lead are examples of non-ferrous metals.

111. **OVERHEAD POSITION OF WELDING:** A welding position in which the plates to be welded are in a horizontal plane and the weld is made on the bottom side of the plates.

112. **OVERLAP:** A defect in the welded joint in which an excess of weld metal extends beyond the zone of fusion.
113. **OXIDE**: A compound of oxygen with another element or substance. Rust and mill scale are examples of oxides.

114. **OXIDIZING FLAME**: A gas welding flame in which the inner cone or that portion of the flame used, produces an oxidizing effect or has an excess of oxygen for balanced combustion.

115. **OXYACETYLENE WELDING**: A gas welding process which depends upon the combustion of oxygen and acetylene for the welding heat.

116. **OXY—OTHER FUEL GAS WELDING**: A gas welding process in which the welding heat is obtained from the combustion of oxygen and any fuel gas other than acetylene. Some of these fuel gases are hydrogen, propane, city gas, and natural gas.

117. **PASS**: The weld metal deposited by one general welding progression along the joint to be welded. Several passes may be necessary to complete a layer of weld metal, as in arc welding.

118. **PEENING**: Mechanical working or stretching of a cold metal surface by means of hammer blows.

119. **PENETRATION**: The depth of fusion obtained in a welded joint. It is the distance from the original surface of the base metal to that point at which fusion ceases.

120. **PLAIN THERMIT**: A mixture of iron oxide and finely divided aluminum.

121. **PLASTIC**: Capable of being molded in solid form by outside force, retaining that form after outside force is removed.

122. **PLUG WELD**: A type of weld used to join two overlapping plates. The upper plate is welded through a hole in its surface to the lower plate.

123. **POROSITY**: The presence of gas pockets or inclusions in weld metal.

124. **POSTHEATING**: Heat applied after welding or cutting operations are completed.
125. **PREHEATING**: Heat applied before welding or cutting operations are started.

126. **PRESSURE THERMIT WELDING**: A pressure welding process in which the heat for welding is obtained from the liquid products (molten metal and slag) of a thermit reaction and the weld is made by pressure.

127. **PRESSURE WELDING PROCESS**: A group of welding processes which require pressure to complete the weld.

128. **PROJECTION WELDING**: A resistance welding process in which the heat for welding is localized between the ends of one part and the surface of another, by means of projections.

129. **REDUCING FLAME**: A gas welding flame in which the inner cone or that portion of the flame used has a reducing or deoxidizing effect.

130. **REINFORCEMENT OF WELD**: Excess weld metal added to strengthen a welded joint.

131. **RESISTANCE BRAZING**: An electric brazing process in which the heat is obtained from the resistance to the flow of an electric current.

132. **RESISTANCE WELDING**: A pressure welding process in which the heat for welding is obtained from the resistance to the flow of an electric current.

133. **REVERSED POLARITY (ELECTRODE POSITIVE)**: The arrangement of direct current arc welding leads so that the work is the negative pole and the electrode is the positive pole in the arc circuit.

134. **ROOT OF WELD**: That portion of the weld metal deposited at the bottom of the welded joint.

135. **ROUGH-FLAME MACHINING**: A flame machining process in which a hand- or machine-guided torch is used to remove large quantities of excess metal in preparation for finish machining with machine tools.

136. **SCARF**: Bevel or chamfer.

137. **SEAM WELDING**: A resistance welding process in which a row of spot welds is made progressively along the
seam of two overlapping sheets. These spot welds may either be adjacent to each other or overlap to make a continuous weld.

138. SHAPE CUTTING: A flame cutting process in which the cutting torch is guided by hand or machine to cut irregular shapes from steel plates.

139. SHIELDED METAL ARC WELDING: A metal arc welding process in which the arc and weld metal are protected from the atmosphere by a shielding gas given off during welding by an electrode coating or flux.

140. SILVER ALLOY BRAZING (SILVER SOLDERING): A low temperature brazing process in which a silver alloy is used as filler metal.

141. SLAG: Excess foreign matter which floats on molten metal and acts to protect the weld metal as well as clean it of impurities.

142. SLAG INCLUSION: Nonmetallic material entrapped in a weld.

143. SLOT WELD: A type of weld used to join two overlapping plates. The upper plate is welded through a slot in its surface to the lower plate.

144. SOLDERING: A process for joining metals by alloys that are fusible and are applied at temperatures below 1000°F.

145. SPOT WELDING: A pressure welding process in which the fusion is confined to a relatively small portion of the area of the lapped parts to be joined. The heat for this process is obtained from the resistance to the flow of electric current in the parts being welded. Pressure is applied by copper electrodes to complete the weld.

146. STACK CUTTING: A flame cutting process in which several thin steel sheets or plates are clamped together and cut in one operation.

147. STRAIGHT POLARITY: The arrangement of direct-current arc welding leads so that the work is the positive pole and the electrode is the negative pole of the arc current.
148. **STRESS**: The intensity of forces acting on or within a body to produce tension, compression, or shear. When present in welded joints they are known as residual stresses due to welding.

149. **STRESS-RELIEF HEAT TREATMENT**: Uniform heating of a structure to a certain temperature below the critical range, followed by a uniform cooling, to relieve or remove a major portion of the residual stresses.

150. **SURFACING**: A process of building up metal surfaces with the choice of surfacing metal depending upon the properties desired.

151. **TACK WELD**: A short weld used to hold assembled pieces in place for welding. By this method of preparation for welding, a desired shape in the welded piece can be maintained.

152. **THERMIT WELDING**: A nonpressure (fusion) welding process for which the heat is obtained from highly superheated liquid steel produced by chemical reaction between iron oxide and aluminum. This steel acts as a filler metal, and the aluminum oxide formed is removed as slag.

153. **T-JOINT**: A weld made at the joint of two plates located at an angle of approximately 90 degrees to each other.

154. **TOE OF WELD**: That portion of the weld located at the intersection of the filler metal and base metal on the surface of the weld.

155. **TUYERE**: A nozzle through which the air blast is delivered to a forge, blast furnace, etc.

156. **ULTRAVIOLET**: Light rays outside the visible spectrum at its violet end. These rays are given off by the arc of an electric arc welding process and by the oxyacetylene flame.

157. **UNAFFECTED ZONE**: That portion of the base metal which is outside of the heat-affected zone and in which no change in physical properties such as strength, hardness, or ductility has taken place as a result of the welding.
158. UNDERCUT: A defect produced in welding in which a portion of the base metal is melted away without the addition of filler metal. This causes a decrease in the thickness of the base metal at this point and therefore weakens the structure.

159. UNSHIELDED CARBON ARC WELDING: A carbon arc welding process in which no gas or other shielding medium is present.

160. UNSHIELDED METAL ARC WELDING: A metal arc welding process in which no gas or other shielding medium is present.

161. UPSET-BUTT WELDING: A resistance butt welding process in which the potential (voltage) and current are applied after the parts to be welded are brought in contact. The heat for welding is obtained mainly from the resistance offered to the flow of current by the metal parts at the joint.

162. VERTICAL POSITION OF WELDING: A welding position in which the plates to be welded as well as the joint are in the vertical plane.

163. WEAVING: A method of depositing metal in which the electrode is oscillated, that is, moved from side to side.

164. WELD: A joint made by a welding process in which two or more metal parts are heated to melting and form one solid piece when they solidify.

165. WELD METAL: The metal in the joint which has been melted in making the weld, including both the added and the base metal.

166. WELDING GROUND: The side of the circuit opposite the welding electrode in electric arc welding.

167. WELDING LEADS: Electrical conductors, usually insulated cables, used to furnish an electrical path between the generator or other source of electrical power and the electrodes.

168. WELDING ROD: Filler metal in wire or rod form, used in the gas welding process and in those arc welding processes in which the electrode does not furnish the filler metal.
169. WELDING TIP: A gas torch tip especially designed for welding.

170. WELDING TORCH OR BLOWPIPE: An apparatus used in gas welding for mixing and controlling the gases.

171. WELDMENT: An assembly, the component parts of which are joined by welding.
SAFETY

Information Sheet

Objective: To acquaint the students with all precautions for personal safety that must be adhered to while using welding equipment.

SAFETY RULES

Storage and Handling of Oxygen Cylinders

1. Oily or greasy substances must be kept away from oxygen cylinders, cylinder valves, couplings, regulators, hose and apparatus. Do not handle oxygen cylinders or apparatus with oily hands or gloves. Oil or grease in the presence of oxygen under pressure may ignite violently.

2. All oxygen and acetylene cylinders carrying I.C.C. markings are manufactured under close inspection, are provided with proper safety devices, and are given most severe tests, as required by specifications established by the Interstate Commerce Commission. But proper construction does not eliminate the necessity of preventing their abuse.

3. All cylinders should carry markings to show that they comply with the regulations of the Interstate Commerce Commission: Oxygen, I.C.C. 3A; Acetylene, I.C.C. 8. No other cylinders should be used for oxy-acetylene service.

4. Comply with all regulations of the National Board of Fire Underwriters and with local state and municipal regulations relative to the storage of oxygen cylinders. Before using cylinders or oxy-acetylene apparatus, obtain and read the Oxweld Instruction Manual and apparatus manufacturers' instructions.

5. Do not store oxygen cylinders near highly combustible material, especially oil, grease or any substance likely to cause or accelerate fire.
6. Do not store cylinders in unusually warm places, such as next to furnaces or radiators. Excessive heat will cause an increase in pressure within the cylinder. Most cylinder valves are equipped with safety devices to release in the event of uniform excessive pressure within the cylinder.

7. Do not store empty and full cylinders together. Assign separate spaces to full and empty cylinders. Use cylinders in rotation as received.

8. Inside buildings, cylinders of oxygen should not be stored in the same compartment with cylinders of acetylene or other fuel gas; there should be a fire-resistant partition between the oxygen cylinders and acetylene or fuel gas cylinders.

9. Where cylinders are stored in the open, protect them from accumulations of ice and snow and from the direct rays of the sun.

10. Store oxygen cylinders in definitely assigned places and away from elevators, gangways or other places where they are liable to be knocked over or damaged by passing or falling objects. Provide a suitable chain or steadying device to keep cylinders in a vertical position and from being knocked over when in storage or use.

11. Never drop oxygen cylinders, nor handle them roughly, nor permit them to strike other cylinders violently.

12. Always keep the valve protecting cap in place and hand tight when cylinder is not connected for use.

13. Never use oxygen from a cylinder without first attaching an oxygen regulator to the cylinder valve.

14. After removing the valve cap, and before attaching the regulator, stand at one side of the oxygen cylinder valve outlet and open the cylinder valve for an instant and then quickly close it. This will clear the opening of dust or dirt.

15. Do not tamper with or attempt to repair oxygen cylinder valves. Never use a hammer or wrench to open cylinder valves. Notify the supplier, if the cylinder valve cannot be opened by hand.
16. After attaching the regulator and before the cylinder valve is opened, make sure that the regulator pressure-adjusting screw is released. Stand at the side of the regulator gauges and barely crack the cylinder valve to allow the cylinder pressure gauge hand to move up slowly. After the gauge hand has stopped moving, open the cylinder valve fully. Do not crack the valve enough to cause the gauge hand to move quickly. A sudden release of high-pressure oxygen might damage the regulator or the high-pressure gauge mechanism.

17. Always open the blowpipe valves a sufficient time to expel any air or mixture that may be present in the hose before lighting the blowpipe, whenever a new cylinder (either oxygen or fuel gas) is connected, or whenever pressure has been cut off in either gas line.

18. When the oxygen cylinder is in use, the valve should be fully open to prevent leakage around the valve stem.

19. Before removing a regulator from a cylinder, or when work is finished, always close the cylinder valve.

20. Manifolds for oxygen cylinders must be of approved design and equipped with pressure regulators. Your oxygen distributor will furnish approved specifications for oxygen distribution pipe lines or installation of oxygen manifolds.

21. Never interchange oxygen regulators, hose, or other apparatus, with similar equipment for other gases.

22. Never use slings or an electric magnet when moving cylinders. A crane may be used only when a cradle or suitable platform is provided. Never lift a cylinder off the ground by means of the valve protecting cap.

23. Never use cylinders as rollers or supports, even if they are considered empty.

24. Always refer to oxygen by its proper name—"oxygen"—and not, for example, by the word "air."

25. Never use oxygen as a substitute for compressed air. Never use oxygen in pneumatic tools, to start internal combustion engines, to "dust" clothing or work, to blow out pipe lines, or for head pressure in a tank of any kind.
26. Do not allow sparks, slag or flame from cutting or welding operations or from any other source, to come in contact with the cylinders, regulators or hose.

27. Oxygen cylinders must not be refilled with any other gas.

28. Return oxygen cylinders as soon as empty. Cylinders are loaned free for thirty-day periods, including the time of transit. Customer is held responsible for safe return, for payment if lost, or for any demurrage that may accrue.

29. The instructor should keep an accurate count of cylinder stocks and see that empty cylinders are promptly returned to the supplier. Before returning cylinders be sure that all valves are closed and that valve protecting caps are in place and hand tight.

30. If a cylinder is found out of order, mark the cylinder defective and return it promptly. Notify distributing station promptly, giving serial number of cylinder and extent of trouble. All cylinders are carefully inspected at the plants before being shipped; but rough handling in transit may damage caps or valves.

31. In checking the contents of oxygen cylinders, proper allowance must be made for low temperature in winter. All cylinders are filled on the basis of 2000 pounds per square inch pressure at 70 degrees F., and before being shipped, are subjected to thorough examinations which include triple checking to insure full capacity and condition. A drop in temperature causes a drop in pressure. Therefore, pressure less than 2000 pounds per square inch at a temperature less than 70 degrees F., does not necessarily indicate shortage.

Storage and Handling of Acetylene Cylinders

1. Always use the name "acetylene". Never refer to acetylene as "gas", because it is far different from city gas, natural gas or furnace gas. Mixtures of acetylene and air have been shown to be explosive through a broad range of mixture; and under certain conditions acetylene may ignite at a temperature as low as 630 degrees F.

2. Avoid abusing cylinders. When cylinders leave the charging plant or warehouse they are in proper condition for safe use for the purpose intended. It is
necessary to prevent their abuse on the job and to keep them in safe condition.

3. Store cylinders only in approved, safe places. Do not store cylinders where they might be knocked over or damaged by passing or falling objects, near flammable or combustible materials such as oil or excelsior, near stoves, radiators, furnaces or other sources of heat, in locations that are damp or poorly ventilated, in the same compartment with oxygen cylinders, unless there is a fire-resisting partition between them, or lying down on their sides. Regulations of the National Board of Fire Underwriters and any local, state, and municipal regulations on storage should be closely followed.

4. Avoid handling cylinders roughly. Avoid dropping cylinders or knocking them together. Otherwise cylinders, valves, or fusible safety plugs may become damaged.

5. When cylinders must be carried, make sure that it is done safely. Take no chances.

6. Keep cylinders from being knocked over or from falling while being moved. Wherever possible use a suitable truck. When moving cylinders by crane or derrick, use a suitable cradle, "boat", or platform. Never use slings or an electric magnet.

7. Never use charged, partly full or empty acetylene cylinders as rollers or supports.

8. Never use a flame of any kind when testing for leaks. Use soapy water.

9. Never tamper with the fusible safety plugs or try to replace them.

10. Should the valve outlet of any acetylene cylinder become clogged with ice, thaw with warm, not boiling water. Never use a flame for this purpose. Remove water as soon as thawing is completed to leave fuse plugs clear.

11. Do not place cylinders in use where they can be damaged by passing or falling objects, near stoves, radiators, furnaces, heated floors or other hot places, or close to cutting or welding operations.
where heat, slag, or hot metal might come in contact with them.

12. Always stand acetylene cylinders with valve end up. Tie, strap, or lash them in upright position to some firm support, using a rope, chain or other suitable means to prevent them from being tipped over.

13. When in use, place cylinders where they can be reached quickly. Make sure there are no obstructions in the way. It should always be possible to shut off the cylinder valve quickly in case the need arises.

14. In order to shut off cylinder valve quickly, always use the special T-wrench or key for opening and closing the cylinder valve. Always leave the T-wrench or key in position on valve stem ready for immediate use.

15. Do not use the recessed top of a cylinder as a receptacle for tools. Tools might interfere with quick closing of the valve and might also damage the fusible safety plugs. Never let this recessed top remain filled with water.

16. Do not open an acetylene cylinder valve more than one and one-half turns. This permits an ample flow of acetylene.

17. Never use a cylinder that is leaking acetylene. If the acetylene leaks around the valve spindle when the valve is opened, close the valve and tighten the gland nut. If this does not stop the leak, close the valve and tag the cylinder as having a defective valve. Notify the supplier and follow his instructions as to its return. If the acetylene leaks from the valve even when closed, or if rough handling should cause any of the fusible safety plugs to leak, move the cylinder to an open place. Tag it as having a defective valve or fuse plug. Open the valve slightly to let the acetylene escape slowly. Place a warning sign at the cylinder not to come near with a lighted cigarette or other source of ignition. When the cylinder is empty, close the valve and remove the cylinder to a suitable location awaiting shipment. Notify the supplier and follow his instructions as to its further handling and return.
18. Use acetylene cylinders only in the normal way. For example, never use acetylene from a cylinder except through an acetylene regulator, and never under any circumstances attempt to transfer acetylene from one cylinder to another, nor to refill an acetylene cylinder, nor to mix any other gas with it in a cylinder.

19. Use a manifold or coupler units to connect two or more cylinders for heavy welding or heating. More than $\frac{1}{7}$ the total capacity of an acetylene cylinder should never be consumed in one hour's operation. Whenever more than $\frac{1}{7}$ the capacity of a single cylinder will be required in an hour, two cylinders or as many more as necessary should be connected together by an approved type of manifold or with approved coupler units.

20. Always follow the proper steps in attaching a regulator to a cylinder. First, stand to one side of the cylinder valve outlet, open the valve very slightly, not over one-quarter turn, for an instant—just enough to clear the valve of dirt or dust—and then close the valve immediately. This action is generally termed "cracking." It should never be performed near an open flame or any other possible source of ignition. Never crack the tank valve any wider, nor leave it open any longer, than is necessary to clear the valve of dirt or dust. Second, attach regulator, pulling the union nut up tight. Third, release the pressure-adjusting screw by turning it to the left until loose. Fourth, open the cylinder valve slowly, always standing away from the front of the gauge faces.

21. Keep cylinder valves closed at all times except when the cylinder is being used. Valves should always be closed before moving cylinders, when work is finished, and when cylinders are empty.

22. Never release acetylene into the air in a confined space or near sparks, flame, or any other possible source of ignition. If it is ever necessary to release acetylene, release it out in the open away from buildings and where a mixture with air will not usually create a hazard.
Safety Rules for Operation of Arc Welding Machines

1. Never attempt to do any maintenance or checking of the welding unit until the disconnecting switch has been pulled.

2. Never use any arc welders, either motor generator or transformer, unless the frame is thoroughly grounded.

3. Never touch at the same time two electrode holders from two separate welding machines. Always avoid contact between any part of the human body and any electrode holder, particularly the exposed or non-insulated parts of any holders or the metallic part of any electrode when gripped in the holder.

4. Never use arc welders with cables having worn or frayed insulation. Worn or frayed insulations reduce the protection of the metallic conductor.

5. Always wear heavy gloves when operating arc welding machines. Avoid contact with the work, with grounded metal and damp or wet earth whenever gloves or clothes are sweaty and damp. Be careful not to sit or lean against the side of tanks or any parts on which welding is being performed if clothes are wet or damp. Wear safety shoes for floor protection. Fully insulated holders give the surest protection.

6. Never stand in puddles of water or on damp ground when welding. Always find a dry board or rubber mat to stand on.

7. Always avoid "eye flash" from an arc welder. An operator should never strike an arc until he is certain that neither his own eyes nor those of anyone else in the vicinity will be exposed to the rays of the arc. Screens and curtains should be used for the protection of others and leak-proof helmets with the proper density of lens must be used by the operator. Eye flash is painful. Exposures should be reported promptly to the authorities.

8. Collect all electrode stub ends in containers provided for this purpose. Stubs on the floor may cause an operator to fall.
9. Always be certain that tarpaulins and all other combustible materials are stored where they will not catch fire from sparks from the arc. Operators should familiarize themselves with the location and use of fire extinguishers.

10. Always avoid hot weld splatter, as it may cause a severe burn, sometimes resulting in infection.

11. Welding machines are often connected in parallel for the purpose of increasing the welding current at the arc. Special precautions must be taken in such cases. Where machines have a common ground, it will be necessary to observe the greatest of care to avoid double voltage between the holders of any two such units. It is recommended that the operator use a voltmeter or light bulb to determine the voltage between all such connections.

12. Two machines with opposite polarity should never be connected parallel.

13. When two DC generators operating with common ground and with opposite polarity are in use, the operators should not come in contact or one operator should not hold both holders.

14. Two AC machines with opposite primary polarity should never be connected in parallel.

15. When transformers are connected to different phases, the secondaries cannot be connected in parallel.
WELDING PROJECTS FOR HIGH SCHOOL STUDENTS

A few projects which are suggestive of the type of metalwork high school students can perform are illustrated here merely as possible problems that would excite the attention of boys in some communities, but not necessarily in all localities. The choice of individual projects should be a student problem, and based on personal need and interest in the work. Every teacher must guide his students in selecting and solving their problems which will vary widely with interests and ability. The thoughts or ideas that arise and the ideals or standards of perfection developed in the minds of the pupils should be the most important value obtained, whereas the object constructed is secondary. Instructors therefore should evaluate student problems by the qualities developed and attempt to point out these accomplishments.
GLASS AND IRON PROJECTS

Designed For

1. Ornamentation
2. Furniture
3. Lighting
4. Windows
5. Doors
TABLE LEG CONSTRUCTION

Material
1. "Tee" or angle iron.

Operations
1. Layout
2. Cut out with torch
3. Heat and bend
4. Weld joints
Material
1. Bar steel
2. Sheet steel

Operations
1. Layout from template
2. Cut out with torch
3. Weld parts together

ORNAMENTAL WORK
<table>
<thead>
<tr>
<th>Material</th>
<th>Operations</th>
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OUTDOOR SPORTS EQUIPMENT
PACK FRAMES FOR BOY SCOUTS

Material
1. Steel tubing
2. Aluminum alloy

Construction
1. Welded
2. Brazed
OUTDOOR SPORTS EQUIPMENT

A. Tubular steel pack frame.
B. Ice axe for climbing.
C. Petons for climbing.
BENCH ANVIL

MATERIAL
1. R.R. TRACK
2. WOOD BLOCK

OPERATIONS
1. CUT WITH TORCH
2. GRIND
PROJECTS FOR THE HOME

1. Children's swing.
2. Clothes line.

Material
Pipe

Construction
Welded
BAR CLAMP

MATERIAL
1. STEEL BAR STOCK
2. \( \frac{5}{8} \) NC BOLT

OPERATIONS
1. CUT WITH SAW
2. WELD
TYPICAL APPLICATIONS OF ARC WELDING
IN MANUFACTURE, CONSTRUCTION AND MAINTENANCE

Aircraft, in industry and in hobbies
Automotive repairs
Boat construction
Bridges and piers
Buildings and houses
Construction equipment
Farm implements, construction and repair
Food plant equipment
Furnaces and heating equipment
Gas plant equipment
Household equipment and fixtures
Jigs and fixtures
Machine parts
Machine tools
Machinery--miscellaneous
Maintenance--miscellaneous
Materials handling equipment
Mining equipment
Oil production
Oil refineries
Ornamental iron work
Pipe lines, oil, gas, and water
Pipe line repair
Plumbing
Pulp and paper mill equipment
Railroad equipment
Railroad maintenance
Rock products and cement plant equipment
Sheet metal work
Shipbuilding
Steel mill equipment
Structural--miscellaneous
Tanks and boilers
Tools and dies
Waterworks and sewerage
