A COURSE OF STUDY FOR ELEMENTARY
OXY-ACETYLENE WELDING
by
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"The smith a mighty man is he, with large and sinewy hands!" These words taken from Longfellow's poem, "The Village Blacksmith," may well be plagiarized to read, "The welder a mighty man is he, with large and sinewy hands!"

The welder, at first, was in many respects a plagiarist of the blacksmith of yesterday. He fused metal not entirely unlike the smith, copying for his own to a degree certain principles of procedure, appropriating various methods and techniques, plagiarizing to effect his birth into the ancillary vocations. Born a weakling, as exemplified by the results of his early welds, he has quite rapidly evolved to become "as strong as iron bands;" until today he finds himself compelled to assume a role of integrity of workmanship and position equally as important as his predecessor, the blacksmith.

No longer is the welder a plagiarist, surviving his period of maladjustment. Severing to a marked degree his affiliations with the blacksmith, he has become divorced unto his own. A certain relationship of an allied nature still exists, for he, which is true of the smith, remains a worker of metals. However, he has grown to the extent
he is now known and recognized in a separate trade of his own formation.

The welding trade, conceived as it was in the blacksmith's process of plastic welding, has developed principally through the fusion process. This method of fusing metals is recognized by its three sub-divisions, as shown in the chart on page 5. Oxy-acetylene welding was the first of these to receive application commercially. It is this branch — oxy-acetylene welding — which affords the field for this present study.

From the standpoint of vocational and commercial values this study is of minor concern; but from an educational point of view, in an elementary informational and operational development, the study should be valuable within the scope of secondary school objectives. To formulate a course of study for welding suitable and satisfactory to the requirements and qualifications for a commercial welder, and at the same time delimit it to the level, aims, and purpose of the high school, would be to favor premature specialization rather than general education.

Specialization resultant from the correlation of basic education and special vocational training is one of the major objectives of an advanced oxy-acetylene welding course, maturing, so to speak, in the development of spe-
cialists or tradesmen. Emphasis in this case would be placed predominantly upon manipulations and techniques. In this elementary welding course, however, it is the aim to give higher correlation of informational and manipulation, with major emphasis upon training in informational or foundational materials.

1. Statement of the Problem. The problem will be to ascertain the appropriate materials to incorporate in the course of study. This will be accomplished by an evaluation and assimilation of the data collected through the mediums of: (1) parallel-group experimental class technique, (2) survey and tabulation of available library source material, (3) job-analysis, and (4) a questionnaire dealing with course of study and objectives.

2. Purpose of the Study. The purpose of the study will be to compile and correlate, by means of written and visual aids, informational and operational units for a course of study in elementary oxy-acetylene welding, showing relationships of educational and vocational value through affiliations with student interests, aptitudes, and abilities.

3. Terminology and Definitions. For the purpose of unifying the meaning of certain terms used in this study, the following definitions are given:

Welding - The term in general usage through this study will imply the meaning of elementary oxy-acetylene welding.
Course of Study - An outline of the contents of study made up of written and visual aids, charts and tables, and informational and operational units. Program of study, course program, and units of study will be used synonymously.

Informational or Operational Unit - A sub-division of a unit; it deals with a separate or specific problem. The following are extracts from a thesis by Cox (3:3-6):

Experience Area - Examples: woodworking, electricity, metal work, transportation, drawing, design, and graphic arts; or social studies and science.

Trade - Some line of skilled mechanical work requiring vocational competency. As applied to a learning situation, the word "trade" usually implies the objectives of vocational proficiency and skill.

General Shop - A type of shop organization in which instruction is given in the informational and the manipulative content of several "experience areas".

Industrial Arts - Variously defined but now generally accepted as a study of the materials, processes, products, and problems of industry, including the social problems and consumer values as well as the technical processes, all for non-vocational purposes and as a definite part of the program of general education.

Vocational - 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.

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CHAPTER II

HISTORICAL STUDIES

1. **Personalism Versus Intellectualism.** Since the turn of the century, two schools of thought have been in conflict concerning the education of the individual. The first school promulgated solely the conception of the intellectualists; to train the intellect for the purpose of understanding the principles of religion, and to this purpose was eventually added, training for the understanding of the principles of the laws of the country. No thought was given to the training of the individual as a whole; only consideration was given to training of the intellect — purely intellectualism.

The following extract, taken from the Massachusetts Law of 1642, reveals the intellectualistic aspect of the educational curriculum in its infancy (12:4):

>This Court, taking into consideration the great neglect of many parents & masters in training up their children in learning, & labor, & other imployments which may be proffitable to the common wealth, do hereupon order and decree, that in every town ye chosen men appointed for managing the prudentiall affaires of the same shall henceforth stand charged with the care of the redress of this evil, ... and for this end, they, or the greater number of them, shall have power to that account from time to time of all parents and masters, and of their children, concerning their calling and imployments of their children, especially of their ability to read & understand the principles of religion & the capitall lawes of this country....
Such training was provided in the home in most cases; no provisions were made for it in the curriculum until nearly one and one-half centuries later. Reading, writing, and Latin were the only subjects to favor the curriculum in its origin, but eventually these subjects were followed with additions of spelling and "Arithmetick" in the formation of the "grammar schoole."

Additional academic subjects were added from time to time to augment the curricula to justify the founding of "the academy." Formal training, as was true of the Latin and the grammar schools, characterized the academy. However, the formalized training of the academy was paramount in paving the way for an enlargement of the curricula to afford certain professional training — the fore-runner of higher education.

Even with the augmentations and the enrichments of the curricula and the innovation of the academy, the educational philosophies remained intellectualistic. It is true, nevertheless, the scope of the educational objectives had developed to a broader point of view in attempting to prepare the individual to react favorably to his life situations, but even so intellectualism remained intrenched in the educational premises.

It was not until the latter part of the nineteenth century that a school of thought in opposition to intel-
lectualism really became evident. Ever-changing vocational and industrial demands had gradually developed into problems with which the intellectualists were unable to cope. Training of only the intellect was insufficient to satisfy these demands; training of the whole individual was evident.

This thought of training the whole individual to successfully take his place in society was propounded by the personalists. Their proponent gradually took root in the secondary schools to eventually effect the introduction of certain commercial subjects. The effect of personalism upon the educational objectives and courses of study is quite concisely explained in the following treatment by Williamson (22:3):

Demands for vocational and industrial education at the high school sic level gave weight to the revolt against entrenched intellectualism. Free and universal secondary education brought an influx of students whose intellectual level and socioeconomic background called for vocational rather than exclusively intellectual objectives. Expanded curricula, vocational subjects, even specialized extrinstructional activities were included to care for increased enrollments and for the new types of students.

The thesis has been advanced by Snedden that secondary school curricula were essentially pre-professional, and only benefited the few who would continue in the learned professions. However, offering educational opportunities only to so select a group is an undemocratic practice. In a democracy, education should serve machinists as well as lawyers. "What we call the 'contemporary movement for vocational education' is in stark simplicity the result of an enormous social
demand for schools for the vocational education of the rank and file of workers! Thus social and economic pressure resulted in schools and colleges adding commercial, and other vocational subjects to the strictly classical curricula.

The expansion of the curricula was extended to include courses of "manual training," developing further into manual arts courses, out of which developed the industrial arts training programs and courses. This last named development is a consolidation of the others, with additions of many units not formerly included in the courses of study.

As pointed out in the introduction, the industrial arts courses provide foundational training for the individual rather than specialized training, which is not true of many vocational trade-training courses. However, in addition to basic training, industrial arts programs offer an exploratory field for the purpose of discovering individual potentialities which may later be developed through specific vocational training. Although affiliated to a degree, each program has its own aims and scope.

Differentiation of the two training programs is necessary in order to understand and appreciate the purposes and limitations of each type of training. Industrial arts courses offer basic study of the materials, processes, products, and problems of industry in terms of general education, while the purpose of vocational education is to provide a more intensive and specialized course of training.
For a time, and to some extent even today, the two different types of programs were recognized synonymously; but clarification of their respective objectives is developing an understanding and appreciation of the contributions each offers in its own field.

For an example, consideration may be given to the differences between the objectives of courses in welding for the two types of programs. The main objective of a vocational course of training is the development of welders who are efficient and skillful, while the industrial arts courses are intended primarily to develop an individual's understanding and appreciation of welding, and some degree of skill, but not necessarily to develop "finished" welders. Neither the nature of an industrial arts course nor the short time allowed for it will permit any valid claim for specialized trade training. Likewise the age and lack of maturity of the students in industrial arts courses make serious trade training largely impossible.

2. **Trends in Courses of Study in Welding.** Shop courses in woodworking were the first to be introduced into the public schools. In the beginning they were very elementary, consisting principally of "things-to-make" courses; but in time their true value gained recognition to eventually effect incorporation into the curriculum of the secondary schools.
Courses in woodworking at first were principally courses in hand-tool operations. Little or no thought was given to objectives other than for something to keep the student occupied. This interpretation of the objectives was not sufficient to satisfy school administrators and instructors of woodworking classes. Through their contacts with the problems involved in the classes and in the organization of the materials for the courses of study, they developed an insight into the educational possibilities to be derived from an expansion of the experience area of hand-tool operations to include some power-tool operations in woodworking.

Out of this movement to expand the experience areas eventually developed the ideas and plans for the general shop which provides for diversified courses of study, including some general metal work. The general shop program serves its purpose very well in offering diversified experiences in preparatory courses, which in turn build a background for more advanced industrial arts courses or for specific vocational(trade) courses.

More recently expansion influences other than movements within the schools have had a noticeable effect upon the enrichment of the curriculum. Influences resulting from industrial developments during and following World War I impressed upon the progressive school admin-
istrators the advisability of further enrichment and expansion of the curriculum to include instructional and operational units in a greater number of the industrial arts subjects. This resulted in the introduction of "general metal work," thus providing many units of training, foundational of course, in allied metal-working courses.

Among the recently recognized courses of training adaptable to secondary school curricula is a unit providing elementary training in oxy-acetylene welding. This unit is very much in its infancy as yet. But with the impetus given it by the present war production program, and even before that by its adoption in a number of the larger secondary schools, it has been recognized as possessing considerable merit. While its purposes and aims have been very much in keeping with those of any other industrial arts subject, the course of study has not been fully developed as welding has been, until recently, more or less dependent upon forging and other related areas. The impetus received during World War II is effecting the divorce of welding from other units, setting it up as an independent course of study.

While in one respect welding is gaining independency as a separate and recognized unit in industrial arts, in another respect it is tending to pass into the specialized trade-training program. Specialization has gained control
of the welding program, due no doubt to the demands for welders as manifested in the present emergency. What influence this will have upon industrial arts courses of study in welding will remain for the future to reveal. At present, because of the existing emergency, specialized training must hold forth. The true industrial arts aspect of such a training program must give ground to the vocational training aspect.

3. Need for an Elementary Welding Course of Study.

The philosophy of educational mass production is surrendering to a more satisfying educational philosophy — education of the individual as an integral part of society. Individual education, or individualized instruction as a more common terminology, involves the analysis and the diagnosis of an individual's potentialities to determine an appropriate educational program in recognition of individual differences. Mass education made little or no provision for individual differences; all individuals were placed in the same educational category regardless of interests, aptitudes or abilities.

The advent of certain commercial and industrial arts subjects into the curriculum of the secondary schools aided materially in breaking down the categorical policies of mass instruction. While academic subjects could be presented "in mass," industrial arts courses could not
be presented effectively by mass instruction methods. Industrial arts subjects are especially adverse to whole group instruction. The nature of the courses, and the materials, processes, problems, and teaching techniques involved all demand recognition of the individual in terms of his differences and potentialities. Each course in an industrial arts program lends itself well to individualized instruction.

This is quite true of a course of study for oxy-acetylene welding. Probably no other course lends itself better to individualized instruction. Each operational unit in the sequential development of individual skills is definitely individualized; only the individual, not the group or class as a whole, develops skills. If there were no differences between individuals a class as a whole would develop skills to the same degree of efficiency. In view of the fact that differences are to be taken into consideration, a course of study in welding is of major importance in the present era.

As a means then of providing for certain individual differences, a course of study in welding is justifiable in any curriculum that includes general metal working courses. The following further justify the need for such a course of study:

1. Values to be derived from the course as a student
appitude survey or exploratory course.

2. A means of aiding in the correlation of the secondary schools and industry.

3. Values to be derived by developing individual understanding and appreciation of welding.

4. Individual development of some manipulative skill.

5. As a possible means of orientating failing students who are mechanically inclined.

6. As an allied or continuation course with forging.

7. A means for foundational training preceding vocational training. (Many students are not capable of going on to college. The secondary schools should be concerned with students' basic trade or vocational training.)

8. An additional means of discovering student potentialities for guidance and counseling.

9. As mentioned, but repeated for emphasis, a means for individualized instruction, especially in operational techniques.
CHAPTER III

THE PROBLEM OF THIS STUDY

1. Limitations of the Study. Certain limitations were mentioned quite briefly in the introduction on page 2, but a more complete treatment is necessary in order to develop an understanding of the field and scope of this study. It is quite necessary to limit the study to a definite area, because of its elementary nature and its foundational aspect. Since it is only a basic course of study with no attempt to provide for vocational training in its entirety, major consideration will be given to correlation of information and manipulation in terms of educational values. Additional limitations of its scope must be considered in interpretation of the purpose of the study in the relationship of student exploration and guidance advantages through individualized instruction, adaptable, of course, to recognized student interests, aptitudes, and abilities.

This study is limited to a course of study in terms of educational values. No attempt has been made to place emphasis on vocational trade-training values which are not directly in keeping with objectives of general education.

Limitations of research methods were also necessary.
The nature and scope of the study permitted use of only the following research techniques: (1) experimental, (2) survey, (3) questionnaire, and (4) analysis. Results from the research studies are explained in the next four sections of this chapter.

2. **Experimental Work Conducted.** During the past two years, 1940-42, the author had occasion to conduct certain experiments. The purposes of the experiments were to determine: (1) the effects of different techniques of welding in developing student skills, and (2) the values of the different techniques employed. The techniques used were selected by means of personal interviews with twenty-two (22) persons affiliated with commercial welding. Conflicting opinions -- opinions differing from those influencing the techniques of welding employed in the school's classes -- opened up the study for the experimental work.

While the interviews and experimental work dealt with both oxy-acetylene welding and electric arc welding, the results have been delimited to exclude arc welding and to present only those findings appropriate for this study.

The results, tabulated on the following page, reveal some very close relationships of techniques. Noticeable
# Tabulations of Experiments

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<th>Group A</th>
<th>Group B</th>
<th>Group C</th>
<th>Group D</th>
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<th>Same As Group B</th>
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<td>B</td>
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**Average:** 85.2% 85.2% 85.2% 85.2%

**Total Differences:** 2.1% 5.2% 2.4% 0.0%

**Letter Values:** A = 95 B = 65 C = 75
among these are: (1) the methods of clockwise weaving in comparison to counter-clockwise weaving of a bead, and (2) the methods of opposite movement of the rod and the torch in comparison to the same movement of the rod and the torch. The other experiments reveal differences, to a degree minor in appearance, yet sufficiently noticeable to merit consideration in selecting techniques for developing skills.

An explanation of the method used to divide the classes into parallel groups is necessary before a more detailed treatment of the results of the experiment may be given. Each year as a student enrolled in the class for training in welding, he was given a number which served for the identification of checked-out tools, his materials, finished exercises, examination papers, notebooks, and projects. The method of numbering the students consecutively furnished a means for dividing the classes into parallel groups. Two groups were formed -- a group of students with even numbers and a group with odd numbers. No provisions were made to eliminate or control any discrepancies of this parallel-group method, in terms of variables or inequalities of the groups. Consideration was given to only a comparison of the techniques of welding selected for the experiment.

Each year as the tests for the various parts of the
experiment were completed they were graded comparatively. That is, the results of a student's work for each test was compared with classified examples of representative work prepared by the author. Three numerical group-values for each technique of the experiment were used: (1) A the 90's, (2) B the 80's, and (3) C the 70's. In order to compute the final averages of the grades only the middle numerical values were used as: (1) A as 95, (2) B as 85, and (3) C as 75.

The numbers are percentage representations of a student's work in comparison to the representative examples of work previously mentioned. The grading of the student test-work by comparisons was more or less subjective, even though it was done by five different persons. Their findings were averaged and the results were recorded in chart form as shown on page 13. After the grades for the 2-year experiment had been tabulated and averaged, the total averages were determined. Comparisons of total averages for the various techniques were made to determine differences.

It was revealed that clockwise and counter-clockwise methods of weaving beads varied only slightly. The difference, 00.8%, in favor of the latter method is due probably to a transfer of training from the Palmer penmanship method for making continuous ovals. Since the comparative results for the two techniques reveal practically no dif-
ference, either method may be used advantageously for narrow weaving.

The results of the filler rod and torch movement tests favor the technique of moving both of them in the same direction simultaneously. The difference, 00.6%, is due to the fact that the simultaneous movements of the rod and torch in opposing direction is less natural for the student. A more noticeable difference was expected from this part of the experiment.

In all other tests the results favored the more generally recommended and accepted techniques -- without filler rod to with filler rod welding, vertical to overhead welding, and the pull method for cutting steel.

All in all results from the experiment favored quite well the welding techniques recommended by the school.

3. Job-analysis. The job-analysis on the following page was considered in terms of the correlation of informational and operational units of instruction. A listing was made of all available topics of informational materials, explained in the fifth division of this chapter. The topics were then arranged in a progressive order, in keeping with the results of the source materials survey. Following this step in developing the analysis came the work of canceling out the more advanced informational materials and reducing the units of information to the scope
| No. | STUDY INFORMATION UNITS | STUDY OPERATIONS UNITS | READ WELDING PLANS | SKETCH A VIEW | MAKE A BILL OF MATERIAL | ESTIMATE COSTS | IDENTIFY METALS | GET OUT STOCK | LAY OUT STOCK | PREPARE STOCK | SET UP WELDING EQUIPMENT | LIGHT A TORCH | USE A CUTTING TORCH | FORM A BEAD WITHOUT FILLER ROD | FORM A BEAD WITH FILLER ROD | TEST A WELD | FINISH OFF A WELD | DO A BUILD-UP WELD | MAKE A FILLET WELD | MAKE A VERTICAL WELD | MAKE AN OVERHEAD WELD | MAKE A ROLLING WELD | MAKE A LATTICE WELD | BRONZE WELD | TEMPER |
|-----|--------------------------|------------------------|---------------------|--------------|------------------------|----------------|----------------|-------------|--------------|--------------|----------------------------|--------------|----------------|-------------------------|---------------------------|-------------|----------------|-------------------|----------------|---------------------|-------------------|---------------|----------------|-------------------|---------------|----------------|----------------|----------------|------|
|     | HOW TO                  | HOW TO                 | HOW TO              | HOW TO       | HOW TO                 | HOW TO        | HOW TO        | HOW TO     | HOW TO      | HOW TO      | HOW TO                      | HOW TO        | HOW TO         | HOW TO                   | HOW TO                      | HOW TO     | HOW TO        | HOW TO               | HOW TO         | HOW TO               | HOW TO               | HOW TO        | HOW TO         | HOW TO          | HOW TO        | HOW TO      | HOW TO        | HOW TO       |
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of an elementary course of study in welding.

Following the selection and organization of informational units, the work of selecting appropriate exercises for operational units was completed. This was accomplished by using a method quite similar to the one used for selecting informational unit topics. The two methods differed, however, in that the operational unit selection method necessitated the correlation of the exercises to the informational units in a progressive order or sequence, dependent in this respect upon the selections for informational units.

In order to evaluate the results of the selections and the organizations, the various units were numbered and arranged as shown on the analysis page. Parallel, broken lines were drawn from the last numbered block of the extreme left-hand column to the last numbered block of the extreme right-hand column. This was done to determine the value of the analysis by the line-block test. Only one unit, number 20, does not contain some part of a numbered block between the parallel lines. This method of testing gives the analysis a 96% value. Another method of testing an analysis is the in-out-block percentage method. The unused blocks on the inside or upper side of the parallel lines are counted and computed as percentages against the used blocks entirely outside the parallel lines. The near-
er this factor approaches 50% the better the analysis. In the case of the author's analysis there are 22 unused blocks for a percentage of 39.4 -- or a variable percentage of -10.6. There are 34 used blocks for a percentage of 60.6 -- or a variable percentage of -10.6.

Variable percentages in excess of plus or minus 8.0, a constant determined by experimental computations, quite generally reveal the fact that two or more units of the analysis are off balance. Of course, one unit could account for the differences, but this is not generally the case.

The final value of an analysis is determined by deducting the total excess variable percentages from the line-block percentages. In the case of the author's analysis the total of the excess variable percentages is 5.2. This amount deducted from the line-block percentage gives a final value for the analysis of 90.8.

In the parallel line-block test the analysis rates very high, while in the in-out-block test the rating reveals an off balance condition of values. The condition was recognized during the development of the analysis, but no favorable means were discovered for remedying it. It is true an analysis may be so arranged as to rate a high value by the methods of testing, the line-block and the in-out-block, but in order to rate extremely high an anal-
ysis, in all probability, would sacrifice its major purpose. That is, the proper sequential organization of the informational and the operational units would receive only minor consideration.

The methods of testing and rating analyses were devised by the author. They are subject to constructive criticism. The methods are not presented as either good or bad, but solely as examples of possible means for evaluating analyses.

4. **Questionnaire Analysis.** A letter of transmittal accompanied by a questionnaire was mailed to each state superintendent of public instruction. The purposes of the questionnaire were to determine: (1) the number of state courses of study that include courses in welding, (2) the number of states now formulating courses of study in welding, (3) the number of state superintendents who deem advisable a state course of study in welding, (4) objectives for courses in welding, (5) the correlational aspect of courses in welding and other allied courses of study, (6) student prerequisite, and (7) the amount of time recommended for a course of study in welding.

Of the forty-eight questionnaires mailed out forty-one were answered and returned. One of these, Michigan, was so incompletely answered the author decided not to count the returns from it in totaling the results. Con-
sequently, the percentage of returns is 83.3%. In a number of cases, those single-stared in the states column on the following page, the questionnaire was answered by the state supervisor of vocational education. In order to compensate for the vocational "trade training" aspect that developed in these cases and to clarify matters, the abbreviation (voc.) was used to denote vocational courses. The statements to follow will in no way include those states not represented in the tabulations of the returns. Furthermore, the statements are concerned primarily with the industrial arts rather than the vocational aspect of the questionnaire returns.

In no instance is there a state course of study that includes welding. There are, however, six states now formulating courses of study in welding, and strange as it may seem the majority of these are in the "farming south"—not in the "manufacturing north". This may be attributed to the fact the farm shop program under the Smith-Hughes act encourages training in elementary welding in relation to other units of training.

In a number of instances the state superintendents favor courses of study in welding. In fact 67.5% checked "yes" on the questionnaire. A study of the states represented in the percentage mentioned above was made to determine sectional differences or trends. The study
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revealed a very general distribution of the states with localization in no particular section of the country. However, the percentage is indicative of a strong favoritism for courses of study in welding.

The results shown in column 4 (a) for the objective "to develop tradesmen only" are indicative of influences of the present war production program. The final result, 37.5%, indicates very strongly the vocational aspect of the trends in trade training in welding. The findings in column 4 (i), like those in 4 (a), also bear out the tendency at the present time toward specialization in trade training programs.

The other objectives offered for consideration in the questionnaire rated quite well with the exception of two. It is true the objectives listed under number 4 as (d) and (f) are of very minor importance, but since they have been mentioned by some educators it was deemed advisable to include them in the questionnaire.

The final results for numbers 5, 6, and 7 are self-explanatory. The various remarks and the correspondence received comprises the closing section of this chapter.

5. Survey of Library Source Material. For the purpose of collecting subject matter appropriate for an elementary course of study in welding, a content survey was made of all available publications dealing with fusion
welding. These books are listed in the bibliography following chapter four.

A number of the books studied were found to be too advanced for the level of secondary school students, especially for students in a beginning course. Such books received very little consideration in terms of elementary subject matter. However, they were weighed and studied carefully as background material, particularly useful to the author. Some publications were found to be too specific; that is they were prepared mainly for one particular purpose -- terminal training or specialization. The publication by Campbell (2) is quite representative of this type of trade-training subject matter. His book was prepared solely for use in training men to make repairs of heavy military ordnance equipment.

In all the survey the author found only three books containing course materials suitable and appropriate in their entirety for elementary courses of study in oxy-acetylene welding. These books include suitable subject matter found in parts in various publications. And, since these books were found to be quite complete and concise, certain units and assignments were adopted from them for use in the author's plan of a course of study in elementary oxy-acetylene welding.

Of the three books selected for subject materials the
one by Rossi (18), because of its arrangement and presentation of subject matter, supplied the major portion of published information used in this study. The books by Plumley (17) and Smith (20) supplied some suitable materials. Smith’s work is comparable to Rossi’s; however, the subject matter organization is not quite in keeping with the plan selected for this study. Even so, it is a commendable publication for an elementary unit plan of study in welding, and it was found that certain materials contained in the book were adaptable for use in chapter IV.

For a terminal-training course of study in welding, the survey of Plumley’s book revealed it to be very worthwhile. It is highly technical and very complete. As a textbook for vocational trade-training courses, it would suffice quite well. But, taken as a whole, it is too advanced for an elementary course. However, certain materials have been adopted from the book for use in chapter IV.

6. Questionnaire Remarks and Correspondence. On the following pages of this chapter are letters of correspondence and various remarks received in connection with the questionnaire:
State of Arkansas
Department of Education
Little Rock

April 25, 1942

Mr. C. H. Oylear
955 Van Buren
Corvallis, Oregon

Dear Mr. Oylear:

Your recent letter concerning a course of study for oxy-acetylene welding for high schools is being referred to Mr. W. J. Breit, State Supervisor of Trade and Industrial Education. You will hear from Mr. Breit in the near future.

Very sincerely yours,

Ralph B. Jones
State Commissioner

RBJ/r

cc - Mr. Breit
State of California  
Department of Education  
Sacramento  
April 23, 1942

Mr. C. H. Oylear  
955 Van Buren  
Corvallis, Oregon

Dear Mr. Oylear:

I am handing your letter under date of April 18, to Mr. J. C. Beswick, Chief of our Bureau of Trade and Industrial Education, for an answer. I am sure that you will hear from his office within a short time.

Cordially yours,

Walter F. Dexter  
Superintendent of Public Instruction

1h9:53:87

Note: The answer to the questionnaire was never received.
Mr. C. H. Oylear
955 Van Buren Street
Corvallis, Oregon

Dear Mr. Oylear:

The questionnaire which you have submitted concerning Oxy-Acetylene Welding for high schools has been filled out and is enclosed.

This office is primarily concerned with Welding courses of a trade and industrial nature rather than the Industrial Arts courses usually provided in the high schools. We are at the present time operating several Welding courses as part of the National Defense Training Program. These courses, as is the custom with all trade and industrial courses, are designed to bring the learner up to production speed in the shortest time. For this reason, the progress record forms which are also enclosed appear to be rather sketchy.

To my knowledge no high school in the state has a regular course in Oxy-Acetylene Welding which might provide the type of information that you have requested. Many schools include some welding as part of their program but no emphasis is given to a rounded training in this work.

I hope the enclosed material may be of some value to you.

Yours very truly,

R. W. Howes
Acting Supervisor
Trade and Industrial Education

RWH:G
Enc.
<table>
<thead>
<tr>
<th>No.</th>
<th>Type of Welding</th>
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<tbody>
<tr>
<td>1.</td>
<td>Setting up apparatus</td>
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<tr>
<td>2.</td>
<td>Ripples flat without rod</td>
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<tr>
<td>3.</td>
<td>Ripples flat with rod</td>
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<td>4.</td>
<td>Butt weld - flat</td>
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<td>5.</td>
<td>Butt weld - vertical</td>
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<tr>
<td>6.</td>
<td>Butt weld - overhead</td>
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<td>7.</td>
<td>Lap weld - flat</td>
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<td>8.</td>
<td>Lap weld - vertical</td>
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<td>9.</td>
<td>Lap weld - overhead</td>
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<td>10.</td>
<td>Corner weld - flat</td>
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<td>Corner weld - vertical</td>
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<td>12.</td>
<td>Corner weld - overhead</td>
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<tr>
<td>13.</td>
<td>Fillet weld - flat</td>
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<tr>
<td>14.</td>
<td>Fillet weld - vertical</td>
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<td>15.</td>
<td>Fillet weld - overhead</td>
</tr>
<tr>
<td>16.</td>
<td>T-weld tubing - horizontal</td>
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<tr>
<td>17.</td>
<td>T-weld tubing - vertical</td>
</tr>
<tr>
<td>18.</td>
<td>T-weld tubing - overhead</td>
</tr>
<tr>
<td>19.</td>
<td>Cluster welding of tubing</td>
</tr>
<tr>
<td>20.</td>
<td>Position welding of tubing</td>
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An Outline and Progress Record of Instruction Units in ARC WELDING

<table>
<thead>
<tr>
<th>Number</th>
<th>Description</th>
<th>Unit</th>
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<tr>
<td>1.</td>
<td>1/4&quot; Fillet Weld - Flat Position - One Pass</td>
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<td>2.</td>
<td>5/16&quot; &quot; &quot; &quot; Two Passes</td>
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<td>3.</td>
<td>3/8&quot; &quot; &quot; &quot; Three Passes</td>
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<td>4.</td>
<td>1/2&quot; &quot; &quot; &quot; Four &quot;</td>
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<td>5.</td>
<td>1/2&quot; &quot; &quot; &quot; Six &quot;</td>
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<td>6.</td>
<td>1/4&quot; &quot; &quot; - Overhead Position - One Pass</td>
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<td>7.</td>
<td>5/16&quot; &quot; &quot; &quot; Two Passes</td>
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<td>9.</td>
<td>1/2&quot; &quot; &quot; &quot; Six Passes</td>
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<td>10.</td>
<td>1/4&quot; &quot; &quot; - Vertical - One Pass</td>
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<td>5/16&quot; &quot; &quot; &quot; Three Passes</td>
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<td>13.</td>
<td>1/2&quot; &quot; &quot; &quot; Three &quot;</td>
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<td>14.</td>
<td>3/8&quot; Single Vee Butt Weld - Flat Position - Five Passes</td>
<td></td>
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<tr>
<td>15.</td>
<td>3/8&quot; Lap Weld - Flat Position - Three Passes</td>
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<tr>
<td>16.</td>
<td>5/8&quot; Single Vee Butt Weld - Vertical Position - Four Passes</td>
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### ConnecticuT State Department of Education

Defense Training Program
March 17, 1942

An Outline and Progress Record of Instruction Units in Arc Welding

<p>| 1. Single Beads in flat position |
| 2. Double beads in flat position |
| 3. Pad of crossing beads in flat position |
| 4. Single beads in 45° flat position |
| 5. Double beads in 45° flat position |
| 6. Pad of crossing beads in 45° flat position |
| 7. Single beads in vertical position |
| 8. Double beads in vertical position |
| 9. Pad of crossing beads in vertical position |
| 10. Single beads in 45° overhead position - welding upward |
| 11. Double beads in 45° overhead position - welding upward |
| 12. Pad of crossing beads in 45° overhead position |
| 13. Single beads in overhead position |
| 14. Double beads in overhead position |
| 15. Pad of crossing beads in overhead position |
| 16. 1/4&quot; fillet weld in flat position |
| 17. 5/16&quot; fillet weld in flat position |
| 18. 3/8&quot; fillet weld in flat position |
| 19. 1/4&quot; fillet weld in vertical position |
| 20. 5/16&quot; fillet weld in vertical position |
| 21. 3/8&quot; fillet weld in vertical position |
| 22. 1/4&quot; fillet weld in overhead position |
| 23. 5/16&quot; fillet weld in overhead position |
| 24. 3/8&quot; fillet weld in overhead position |
| 25. Lap weld in flat position |
| 26. Lap weld in vertical position |
| 27. Lap weld in 45° overhead position - welding upward |
| 28. Lap weld in 45° overhead position - welding horizontally |
| 29. Lap weld in overhead position |
| 30. Butt weld in flat position |
| 31. Butt weld in vertical position |
| 32. Butt weld in overhead position |
| 33. 3/16&quot; fillet weld on galvanized material - flat position |
| 34. 1/4&quot; fillet weld on galvanized material - flat position |
| 35. 5/16&quot; fillet weld on galvanized material - flat position |
| 36. 3/8&quot; fillet weld on galvanized material - flat position |
| 37. 3/16&quot; fillet weld on galvanized material - vertical position |
| 38. 1/4&quot; fillet weld on galvanized material - vertical position |
| 39. 5/16&quot; fillet weld on galvanized material - vertical position |
| 40. 3/8&quot; fillet weld on galvanized material - vertical position |
| 41. 3/16&quot; fillet weld on galvanized material - overhead position |
| 42. 1/4&quot; fillet weld on galvanized material - overhead position |
| 43. 5/16&quot; fillet weld on galvanized material - overhead position |
| 44. 3/8&quot; fillet weld on galvanized material - overhead position |
| 45. Butt weld on galvanized material - flat position |
| 46. Butt weld on galvanized material - vertical position |
| 47. Butt joint welded horizontally in vertical plane, using multiple beads |
| 48. Butt weld on galvanized material, overhead position |
| 49. 1/4&quot;, 5/16&quot; and 3/8&quot; fillet welds &quot;in the groove&quot; - weld straight down - must be exact shape and size |
| 50. Welding countersunk holes in flat position |
| 51. Welding countersunk holes in vertical position |
| 52. Welding countersunk holes in overhead position |
| 53. Instruction and practice in oxy-acetylene cutting and heating |
| 54. Preliminary qualification test plates as required by Navy Dept., Steamboat Inspection, A.B.S. or Lloyd's |</p>
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<tr>
<th></th>
<th>FLAT</th>
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INSTRUCTOR'S COPY

STUDENT TIME AND PROGRESS RECORD
Mr. C. H. Oylear
955 Van Buren Street
Corvallis, Oregon

Dear Mr. Oylear:

Your request for information on our procedure with regard to a course of study for welding has been referred to me for reply.

I have answered your questionnaire assuming that you are interested in welding only as in day school classes. Our evening and part-time welding classes are only for the purpose of developing skill under special license. Much of our welding in defense in now "down hand" or "horizontal."

Several cities have requested welding in day school course on a full time industrial basis. Frankly, we have hesitated to approve such courses. Right now I have at least one city director who is in the process of getting evidence from his advisory committee and his local industries as to the need for such a course. His evidence has not yet been presented and I am inclined to think that at the present time, it is only an addition to machine shop.

I am enclosing page two of your questionnaire.

Very truly yours,

H. G. McComb, State Director of Vocational Training for Defense Workers

HGMe/FAM
Enc.
Mr. C. H. Oylear
955 Van Buren
Corvallis, Oregon

Dear Mr. Oylear

Your letter written April 18 to the State Department of Public Instruction, asking for certain information relative to oxy-acetylene welding training as given in the high schools of this state, has been referred to me for reply.

Our state course of study for Industrial Arts Education does not include any instructional outline for this type of training. Prior to the emergency, which we are in at the present time, very little training for acetylene or arc welding was given in either industrial arts or vocational education.

The nature of the questions as found on your questionnaire would indicate that you are seeking information as to a training program for industrial arts education. I would not be in a position to give you this information.

I will say, however, that since the program for training of defense workers has been initiated in this state, we have set up rather an intensive program to prepare workers for defense industries. The major portion of our courses starting one year ago gave about an equal amount of instruction for gas and acetylene. However, we are informed by the United States Offices of Education that the War Production Board asks for about one acetylene welder to nine arc welders. This being the case, we are no longer installing acetylene welding facilities. All new equipment which is being installed at the present time is for arc welding.

Our obligation is to train men for specific types of jobs in defense industries. Job specifications
are given and we provide instructional material to prepare the men for the type of service needed. The major portion of our training courses last 300 hours. After this time, if the right kind of trainee has been selected, he will be capable of doing the job required of him by industry.

I am marking your questionnaire. However, in view of the information given in the previous paragraphs, you will understand that the training situation in this state does not have much relation to its content.

With kind regards, I am

Yours very truly,

Ross C. Cramlet
Assistant Supervisor
Defense Training
May 12, 1942

Mr. C. H. Oylear
955 Van Buren Street
Corvallis, Oregon

Dear Mr. Oylear:

Your questionnaire concerning welding has been handed to me for reply.

As you will notice, our State does not have a course of study for welding on the industrial arts level. Kansas City, Kansas, is the only place that we know anything about where welding is being taught, excepting as incidental to farm shop and general shop. If you care to have further information regarding the Kansas City course of study, you may write to L. E. Falgren, Director of Industrial Education, Ninth and Washington Streets, Kansas City, Kansas.

Yours very truly,

O. H. Beaty
Assistant State Supervisor of Trade and Industrial Education
State of Louisiana
Department of Education
National Defense Division
Baton Rouge

April 29, 1942

Mr. C. H. Oylear
955 Van Buren Street
Corvallis, Oregon

Dear Mr. Oylear:

I have your letter of April 13 submitting a questionnaire on welding. I am returning the questionnaire with my response indicated. I do not feel that welding in true industrial arts programs has a place at all.

Cordially yours,

Andrew Triche, State Supervisor of Trade and Industrial Education

AT:ab
Enclosure

Note: The enclosure, the questionnaire, was never received.
Mr. C. H. Cylear
955 Van Buren Street
Corvallis, Oregon

Dear Sir:

In reply to your communication of April 18 requesting information on welding courses in high schools, I am sorry to say that these are not included in our curriculum. The only welding courses connected with the Department of Education are those offered under the Defense program. These are conducted in South Portland and Bath and are to train workers for the Bath Shipbuilding Co. and the Todd-Bath Shipbuilding Co.

Sincerely yours,

Austin Alden
Director of Vocational Education

Note: The questionnaire was never returned.
CHAPTER IV

SELECTION AND FORMULATION OF UNITS OF STUDY

1. Method of Procedure in Selecting and Formulating Units for the Course of Study. During the past four years (1938-42), the author selected and formulated courses of study for various units of work in a general metal shop at the high school level. The courses in metal work, all elementary by nature, of course, included units in the following experience areas: (1) forging, (2) oxy-acetylene and electric arc welding, (3) foundry practice, (4) machine shop practice, (5) bench metal work.

The units of study in each of these areas were made up of informational and operational materials. Major consideration was given to the informational units -- approximately on a 60-40 percentage basis. All courses were designed to offer basic or "foundational" training; consequently, the operational units, because of their lesser importance in such a program, were included mainly for the purpose of: (1) developing certain manipulative skills, (2)affording exploratory possibilities in relation to informational units, (3) furnishing a broader guidance background, (4) developing appreciation and understanding of operational techniques employed in welding.
The first year the classes were organized, it was difficult to determine appropriate units for the courses, especially in the welding area. It was required by the school administration that the newly organized shop classes provide for construction of most equipment needed in setting up the shop, such as benches, stands, etc. This request necessitated prompt training of certain students for certain types of work to be performed in the construction assignments. Boys were singled out to do forging, welding, carpentry work, painting, sheet-metal work, and cement work. Short units of training for such types of work were pushed to the utmost. Very little time was given to the study of related informational materials; development of skills sufficient to perform the required jobs was of major concern. "Rush the boys through a minimum of operational training and get the shop set up," was the cry from the office.

The orders were carried out in a minimum amount of time, but the educational results of such a procedure were rather negative. It is true certain boys learned to perform certain specific operations in a very limited time. However, when an analysis was made later and subject-matter examinations were given, it was revealed that the method of training students in only certain specified experience areas was decidedly not in keeping with the objectives of a program for general education at the high school level.
Such a procedure of training in skills only is inefficient in many respects, some of which are:

1. Failure to develop an understanding of informational materials.
2. Unequal educational opportunities for the students.
3. Insufficient time for proper demonstrations, examinations, student explorations into varied experience areas, proper treatment of informational materials, guidance considerations, and proper recognition of student interests, aptitudes, and abilities.

Out of the "hodge-podge" of this first year there developed for the author an understanding and an appreciation of things to do and things not to do in selecting and formulating units for a course of study in general metal work.

The experience aided materially in the preparation of the later course of study. In place of one general course of study, a course was developed the following year for each of the units listed in the first paragraph of this chapter. Also, a reversal of emphasis was effected. Informational units or topics received major consideration, while the operational or manipulative work was subordinated to the needs of the informational topics. More informational units were incorporated in the program, in keeping with the plan of reorganization. In the program for welding, safety measures were emphasized in order to overcome accidents. The need for additional related information regarding welding processes, lines of stress, materials, produc-
tion of gases, types of equipment, types of flames, the kinds and uses of welds -- that need was satisfied by developing or selecting appropriate information units for that phase of instruction. Then suitable exercises for the corresponding operational units were selected from recommendations made by experienced welders, from publications by Plumley (17), Smith (2), and the Linde Air Products Company (15).

After the selections of the informational and operational units had been made, they were arranged in a sequence rather in keeping with plans of organization as adopted by Plumley (17) and Smith (20). That is, general introductory units of study made up the first part of the course, followed by other units in the order of their progressive relationships.

The following year still more units were added to the course to include information dealing with template development, methods of study, testing of welds, built-up work, and tubing welds. As some units were added in recognition of needs for certain subject matter others were excluded in order to balance or round out a desirable course of study. For example, the welding of aluminum was one unit in particular which was dropped from the course. This unit proved to be too highly specialized for most of the students.
In the fourth year only three changes of importance were made in the program. The experiments explained in a previous chapter suggested or rather revealed the advisability of effecting certain changes in the unit sequence. The two changes made in keeping with results of the experiments were:

1. Lap welds to precede fillet welds in the unit sequence.

2. Contrary to recommendations of certain commercial welders, vertical position welds were changed to precede overhead position welds in the unit sequence.

The third change was made as a means of correlating occupational information with the course-of-study information. This was accomplished by arranging time for field trips so the classes could visit the railroad repair shops and various commercial shops in order to gain first-hand occupational information about welding as a vocation.

The present course of study, as outlined in Appendix A, was developed out of the experience gained by the author in these four years of trial and error, plus that information gained from interviews with commercial welders. Portions of the course are adoptions from publications by certain recognized authorities on courses of study for welding. This is particularly true of certain instructional units, as acknowledged elsewhere.
CHAPTER V

SUMMARY, IMPLICATIONS, and RECOMMENDATIONS

1. **Summary.** This study was undertaken for the purpose of selecting and formulating appropriate units of study for a course in elementary oxy-acetylene welding, with the hope that it may be of value in teacher education centers, and to prospective teachers who are often in doubt as to subject matter organization for a course of this type.

The various terminologies and definitions incorporated in the study are included to effect uniformity in developing understanding and appreciation of words used in the realm of industrial arts, and particularly in welding.

In summarizing, there are numerous problems common to a study of this nature, including the assimilation and segregation of course materials, and the analysis and formulation of appropriate units of study. Conflicting educational philosophies -- education for the individual as a whole in opposition to education for all en masse -- also constituted a problem, and industrial and vocational demands merited consideration. Other problems necessarily considered in formulating the course of study were: (1) maturity of the trainees, (2) types of communities in which the course is to be offered, (3) justifications for
the course, (4) purposes of the course, for industrial arts or for vocational training, (5) school enrollment, (6) amount of time for the course, (7) general educational values to be derived, (8) factors of guidance, (9) relationships to other courses, (10) shop equipment and facilities, (11) comparative costs, and (12) the general objectives of the course in terms of the stated objectives of education at the high school level.

The study was limited in scope to its application as a "unit" or an experience area in elementary oxy-acetylene welding suitable only for the general metal shop catering to the objectives of industrial arts. There is no intention to claim any serious vocational objectives.

Four techniques or devices were used in collecting materials for the study. They consisted of:

1. Experimental work
   Experiments with certain techniques of welding to determine the proper ones to teach.

2. Job-analysis
   An analysis to evaluate the selection and organization of the units of study.

3. Questionnaire
   To determine, (1) the number of state courses of study including welding, (2) the number of states formulating courses of study in welding, (3) the objectives of courses in welding, and (4) the amount of time recommended for an elementary course in welding, to meet industrial arts rather than trade objectives.
4. Survey of library source materials
To determine what various authorities on welding courses recommend under similar circumstances.

From the materials surveyed, from the interviews with commercial welders, and from experience gained by the author in teaching welding classes, the course of study in Appendix A was developed. It is presented in the belief that it may have some value to others as well as to the author.

2. Implications. The response to the questionnaire indicated a very good interest in the study, especially on the part of vocational directors and supervisors. A response of 83.3% was secured, much higher than is usually the case with the average questionnaire study.

The questionnaire was designed for limitation to only state superintendents of public instruction; however, a number of state vocational directors answered for the superintendents. The substitution of officials in certain cases undoubtedly affected the answers to the questions. This was indicated in the vocational trade-training trend or aspect in the final tabulations and findings of the returns. Indications are, at the present time, that courses in welding favor or tend to favor manipulative training more than informational training. This, of course, is somewhat contrary to industrial arts objectives and is a reflection of the vocational influence. Since the present
influence is coming largely from defense training programs set up for the war emergency, general education objectives of nearly all industrial arts courses must favor, for the time being, the vocational trade-training objectives.

Not mentioned in the study, yet of importance in the area of industrial arts, is the fact that defense training programs have become more difficult to administer and to carry out as initially planned. The difficulty lies in that all available skilled and semi-skilled labor has been absorbed, and the defense training program is now confronted with the problem of giving basic as well as specific training to all trainees. In the beginning of the defense program, there were available fundamentally trained people, broadly acquainted with industrial processes through contact with industrial arts causes, from which enrollments could be made. But this field is now largely exhausted and it has become necessary to expand the whole program to include units in fundamental training of the industrial arts type, whether in schools or in the defense industries.

This condition could have been alleviated quite materially had the World War I information and data received proper analysis and diagnosis by school administrators. Changes could have been effected for expansion of the curriculum to better satisfy needs of ever-changing industrial and social orders. Had the changes been properly admin-
istered, the present problem of the defense training pro-
gram regarding the selection and preparation of trainees
would, no doubt, be less serious.

The implication of this whole problem is that many
weaknesses of educational philosophies revealed during and
following World War I will present themselves again during
the forthcoming social and economic reorganizations. Unless
educators are aroused to realize and appreciate fully the
importance of industrial arts courses in the social orders
of the day, curriculum revisions and expansions to afford
equal and satisfying educational opportunities in industrial
arts programs will be neglected in consideration of more
academic and formalized courses of training. All persons
concerned should do everything possible to assist in es-
tablishing firmly in the public mind the importance of
industrial arts courses in the junior and senior high school
curriculum. Equal educational opportunities should be pro-
vided for all.


APPENDICES

SUPPLEMENTAL SECTION OF THE STUDY

Appendix A. Course of Study
Appendix B. Optional Units of Study
Appendix C. Factors in Shop Demonstrations
Appendix D. Letter of Transmittal
Appendix E. Questionnaire
Information Unit I

Measures of safety as applied to procedures in a school or industrial shop resolve into one’s using common sense and good judgment. Machinery of modern times is equipped with guards and devices designed to afford protection to the operators and make operation of equipment as safe as possible. However, statistical surveys reveal that guards and other safety devices afford only 15% protection. Thus, 85% of all accidents in school and industrial plants is due to a factor or factors that cannot be properly guarded against by mechanical means. The human element is the principal factor accounting for this high percentage of, to a certain degree, preventable accidents. Most accidents are due principally to someone’s thoughtlessness, carelessness or lack of consideration of the rights of others, and may be overcome appreciably through the understanding and appreciation of safety measures.

Safety is principally a matter of endeavoring earnestly to learn and follow safe practices and procedures at all times. It is, in reality, much more a matter of do’s rather than don’t’s.

Specific applications are:

1. One should always apply first-aid treatment to cuts or bruises, regardless of how slight. Allowing a slight
cut to bleed a minute or two is good practice, as free bleeding will aid in carrying off infectious materials that may have gained entrance to the wound. Severe cuts or bruises should receive the immediate attention of a physician.

2. A burn should be treated promptly, according to its degree of severity. The kinds of burns are:

First degree burn -- the skin is merely reddened.
Second degree burn -- the skin is blistered.
Third degree burn -- the flesh is seared.

First degree burns may be treated with an application of baking soda and water, or carbolated vaseline, or a good burn ointment. The other kinds of burns require the immediate attention of a physician.

3. One should avoid standing in his own light.

4. Playing, carrying on needless conversation, shouting, whistling, or acting in a boisterous manner are invitations to accidents. Undivided attention to one's work is quite essential.

5. Grasping with the hands metal which may be hot is simply flirting with danger. It should first be tested with a moist finger.

6. Goggles or shields should always be used while operating grinding tools. The same practice applies while chipping metals.

7. The tool rest for grinding machines should always
be set up close to the grinding wheel.

8. Contacting the revolving grinding wheel with the fingers must be avoided.

9. Short pieces of stock while being ground should not be held in the hands. The use of holding devices is recommended.

10. All safety appliances should be in place before a machine is started.

11. One should avoid glancing blows while using a cold chisel.

12. Care should be exercised regarding the direction of flying particles while chiseling or chipping metals.

13. Tools with mushroomed or battered heads should be reconditioned before using.

14. A file tang should always be equipped with a handle.

15. Stock gripped in a vise should never extend across an aisle or a passage-way.

16. Tongs or holding devices are to be used while handling hot metals. Kicking them or slapping them around is very dangerous.

17. Hot pieces of metal should not be left around unguarded.

18. Assistants must be acquainted with points of danger and plans of procedure.
19. During welding operations, proper protection for the eyes and the hands must be provided, and used.

20. Proper ventilation is of vital importance. Disregard of this factor may result in an explosion of escaping gases.

21. Dangerous or inflammable materials should be protected from welding operations.

22. Adherence to rules and procedures for setting up equipment, handling the various types of equipment, replacing equipment, and properly caring for work areas makes for safety.

23. The act of holding a lighted torch in one hand while setting up a welding operation with the other hand is extremely dangerous. The work should be set up beforehand.

24. The hoses should never be allowed to become twisted or knotted or come in contact with oil or grease. Too, hot metals and flames must not contact the hoses.

25. Tank welding is dangerous and should be done by an experienced person.

26. Cutting into a tank or a drum calls for experience, and the operation should never be started until the materials formerly contained therein are known.

27. Flying sparks and slag from a cutting torch operation demand consideration for their control.

28. Cement and other similar materials will explode
when heated as with a torch. Care must be exercised in welding or cutting near such material.

29. The operator should consider his position regarding safety when performing welding operations, especially vertical and overhead welds. The same consideration applies for cutting operations.

30. Quite often a "short cut" is a quick way to an accident. The element of danger should always be taken into consideration in planning an operation or a piece of work.

31. Danger, like a boxer, is always ready to take advantage of a person who is off guard. The guard must always be kept up.

32. One should STOP, LOOK, and THINK before proceeding in a dangerous or definitely unknown and unfamiliar situation.

33. A good criterion of a careful workman is; A careful workman is seldom involved in an accident.

34. One should bear in mind; not safety last, but safety first always.

Consideration:

Part of a student's grade should be in consideration of his application of safety measures. To teach and train a student in only manipulative skills, with no regard or consideration for his safety training, is inane and quite
beyond the point of a highly commendable shop training program. Too often the results of a training program, which neglects or only simulates safety training, eventually manifests itself in the form of preventable accidents. Proper and effective training for safety will effect a reduction of the high percentage of accidents, and at the same time make for a better world in which to live.
EXPLANATION OF INFORMATIONAL AND OPERATIONAL UNITS

Information Unit II

The units to follow deal with either or both materials of information and of operation. Some units are decidedly of one specific type, while others are a combination of both informational and operational course materials. They are assimilations of units or assignments in oxy-acetylene welding prepared by: the author, Harcourt (6), Plumley (17), Rossi (18), Schwarzkopf (19), and Smith (20).

Each of the first few units, numbers three to twelve inclusive, is treated separately as a unit of information. This group of units deals with general course material which is introductory to the topics of study that follow. The next unit in order, number thirteen, is made up primarily of six informational divisions. These divisions are included in the course for the purpose of providing instructions in introductory procedures related to the units of study in general. Number fourteen is informational material, but it may satisfy the requirements of an operational unit provided suitable metals are furnished for the various tests. Unit fifteen is made up of three informational divisions which deal with materials to be used in following specified operations. The remaining units are correlations of informational and operational materials.
Information Unit III

Processes: The processes used in welding steel can be classified into two main groups, which are designated as plastic welding and fusion welding. In the first group, page 4, are those processes which require that the pieces of steel be heated to a plastic state and then forced together by external pressure. This procedure is used in forge welding and in electric resistance welding. In the second group are gas welding, electric arc welding, and "thermit" welding. In each of the fusion welding processes, the material at the joint is heated to a molten state.

The surfaces to be joined by any of the welding processes must be sufficiently clean that cohesion will take place when the metals are in a plastic or fluid state. The presence of oxides on the surfaces to be welded together interferes with the cohesion of the metals. Since oxidation proceeds more rapidly with an increase in temperature, special care is taken to prevent the formation of oxides or to assist in their removal at the welding temperatures. In many cases materials known as fluxes are applied to the parts being welded, to dissolve the oxides and thus permit clean, metallic surfaces to come in contact.
Gas Welding: Various gas combinations can be used for producing a hot flame for welding metals. Acetylene (C₂H₂) and oxygen (O₂) are in general use, although hydrogen and oxygen serve well for some purposes. These gases are thoroughly mixed in correct proportions in a torch and are ignited at the tip.

The equipment required for oxy-acetylene welding includes cylinders containing oxygen and acetylene, a suitable hand torch, and rubber hose to connect the torch to the gas supply. Automatic regulators are used to reduce the pressure of the gases from that in the usual trade cylinders down to the pressures suitable for welding. The cylinders, illustrated on page 66, and the regulator used for oxygen, page 67, are very necessary equipment in gas welding. Also, on the same page illustrating the sectional view of an oxygen regulator is a sectional view of the mixing chamber of an equal pressure torch. Immediately below this sketch is a cutting torch in sectional view, showing the various parts. The desired proportions of the gases are adjusted by the valves on the torch, and these gases are thoroughly mixed before issuing from the tip. A number of interchangeable tips are provided with each torch so that flames of different sizes can be obtained. When oxygen and acetylene are supplied in nearly equal volumes, a neutral flame is produced having a maximum
Diagrammatic Sketch, showing Cylinders, Regulators and a Torch properly connected and ready to operate.
Adopted from Plumley (17-20)

**Sectional View Through the Mixing Section and the Head of the Torch Handle of An Equal Pressure Torch Showing the Mixing Chamber.**

**Sectional View of a Cutting Torch. Cutting Torches Have Both Oxygen and Acetylene Valves, Controlling the Preheating Flames at the Tip of the Torch. They also have an Additional Valve Controlled by a Lever or Button which Shuts off and Turns on the Cutting Jet of Pure Oxygen Issuing from a Hole in the Tip Located Centrally Between the Preheating Flames.**

**Sectional View of An Oxygen Regulator Showing the Nozzle, Seat and Other Internal Parts.**
temperature of about 6300 degrees F., page 87. As the proportion of acetylene in the gas mixture is increased, a reducing flame with a lower temperature is obtained. It is therefore possible to control both the temperature and the atmosphere at the weld when using the gas torch.

Acetylene in combustion combines the carbon with oxygen to form first, carbon monoxide, which combines with oxygen from free air to form carbon dioxide (CO₂). During the time while the oxy-acetylene gas issues from the torch into the hot flame, the acetylene dissociates into carbon monoxide and hydrogen. The result of this reaction is the production of the bright inner cone of the neutral flame. In the hot outer flame the carbon monoxide and hydrogen combine with the oxygen from the surrounding air, forming carbon dioxide and water vapor. This action produces the bluish enveloping flame surrounding the bright inner cone. When there is an excess, even slight, of acetylene, the flame will consist of three distinct cones instead of two. This is called a reducing or carburizing flame and is used in welding steel by what is known as the Lindewell process.

This process can be used with most all weldable metals. Among these are mild steel, steel castings, alloys of steel, cast iron -- both gray and white, brass, bronze, copper, nickel, monel metal, aluminum, and certain precious and semiprecious metals. Unlike metals also may be welded, as,
for example, cast iron and steel.

When welding unlike metals, such as mild steel and cast iron, one should use a welding rod similar to the metal having the lower welding point. In this case, a cast iron filler rod should be selected for the operation. Another method quite commonly employed to fuse unlike metals is the bronze weld method, explanation of which will be given in a later unit of information.

Informational units to follow in the course of study include detailed information, more of a specific nature, relative to gas welding processes. The page immediately following is rather self-explanatory, in that it deals with certain symbols and nomenclatures of welds.
Stresses in a plate or a bar may be indicated by parallel lines, as shown at F, middle sketch on page 71. This sketch shows a hole in a plate and indicates the fact that these stress lines must pass around the hole rather than straight through it, as they would if the plate were solid. If there were no hole in the plate, the stress lines would be parallel across the entire area of the plate as they are at the top and the bottom. With a hole, such as is shown, however, the stress lines must concentrate, or become bunched, on either side of the hole as indicated. This means that the stress at these points must be greater to resist the tendency of the external forces to pull the metal apart. If the external force is greater than the stress at these concentrated areas, the metal, if cast iron, will break. If the hole were not present the stress lines would not be concentrated, and the external pull would be evenly distributed over the entire area and, therefore, unlikely to break the iron.

A similar condition exists in the sketch at the top of the page, as shown at C and also at B. The sketch at the bottom of the page illustrates the ideal condition, in which the parallel stress lines indicate no concentration whatever. The pull, therefore, is distributed evenly.
Drawings by Plumley (17:168-169)

Sectional View of a Collar Type Bronze Welded Joint Showing the Stress Lines, F, Passing Upwards Through the Bronze Collar, B-C. The Concentration of these Lines at the Points B and C Is Clearly Indicated.

Sketch of a Plate with a Hole in It, Showing the Concentration of Stress Lines at the Edges of the Hole. The Stress Lines, F, are Indicated by the Arrows and Must Pass Around the Hole.

Sketch Illustrating a Vee Type Joint, Showing the Stress Lines, F, Passing Uniformly Through the Joint and Indicating No Concentration Whatever.
Information Unit V

Laying Out a Templet for Cutting a 90 Degree Elbow

by a method explained by Plumley (1766):

... the construction is shown (following page) of one of the simplest forms of templets. It is the templet used for cutting the ends of two pieces of pipe of the same size to form a single weld ninety degree elbow. To develop this templet first a full size outline of the fitting is made as at A. Then, as shown, a semi-circle is drawn having a diameter equal to the diameter of the pipe and the circumference of the semi-circle divided into any number of equal parts. ... (the drawing) shows the semi-circle divided into twelve parts. From each of these eleven points lines parallel to the sides of the pipe have been projected until they meet the line representing the joint between the two pieces of pipe. These lines are called ordinates. Each of these ordinates should be numbered as indicated.

It will be noted that all of the ordinates, with the exception of the edge of the pipe, have two numbers. If instead of drawing only a semi-circle, a complete circle was drawn, points 12 and 14, 11 and 15, 10 and 16, etc., would be exactly opposite each other on the circle and a line drawn through point 12 parallel to the sides of the pipe would pass through point 14. Therefore, in order to simplify the drawing, it is customary practice to draw only a semi-circle and to give each point except the edges, two numbers. When numbering these ordinates, an edge of the pipe should be called number 1 and the numbering continued consecutively until the opposite side is reached, then back again until the first side is again reached. Next, a line should be drawn, such as C-C, at right angles to the pipe, as illustrated. This line may be at any convenient distance D from the joint and merely serves as a reference line when measuring the length of the ordinates.

After all of the above steps have been completed, a line should be drawn exactly as long as the circumference of the pipe, shown as C-C, at B. This line is called the base line, and is carefully divided into twice the number of equal parts as the semi-circle.
This Drawing Shows the Development of a Template for Cutting the Ends of Pipe to Make a Single Welded 90 Degree Elbow. The Completed Template is Shown at B.
in A and lines perpendicular to C-C are erected at each of these points. The line at each end is numbered 1, and, starting at the left, the next line is numbered 2, the next 3, etc., until all of the lines are numbered.

Now, a pair of dividers, a rule or other measuring device, is used to lay off on line number 1, in B, the exact distance on line 1, in A, from line C-C to the joint between the two pieces of pipe. Next, the distance along line 2, 24 in A, from line C-C to the joint, is laid off on line 2 and 24, in B. This method is continued until all of the intersections of the ordinates and joints in A have been marked on the corresponding lines at B. The next and final step is to connect these points with a smoothly curving line, such as the illustrated at B.

Because both pieces of pipe, in this case, are cut at an angle of 45 degrees, it is necessary to make only one templet.
### Information Unit VI

#### Weight of Flat Iron per Lineal Foot

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*Note: The table above provides the weight of flat iron per lineal foot for various thicknesses and lengths. The weights are given in pounds. The table is useful for construction and metalworking projects where precise measurements of materials are required.*
## Weight of Round and Square Iron per Foot

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On the following page are several sketches illustrating the appearance of sparks thrown by a grinding wheel when pieces of various grades of steel are held against it. Not included among the sketches, yet a metal the welder or metal-worker should easily identify, is a metal known as cast iron.

It has much less strength than any of the steels illustrated, is less pure and is brought to its final shape by melting the iron and pouring it into a mold. A typical sample of cast iron contains about ninety-four or ninety-five per cent of iron, three to four per cent of carbon and about two per cent of various impurities. Cast iron, when broken, is a dark gray and the grain is decidedly granular and coarse. When it is held against a grinding wheel, sparks are given off which are quite similar to those produced from tool steel. However, they are more numerous, and at first are dull-red, finally changing to a golden-yellow.

In order to observe properly the colors and the sparks produced by the grinding wheel test for cast iron, or any other metal being tested, the operator should take a position to the side of the machine. The sketches will assist one in identifying various kinds of steels as illustrated.
1. Wrought iron. Sparks thrown from the wheel will follow a straight line. The sparks will become broader and more luminous some distance from the wheel and then disappear in a straight line. The carbon content is from 0.02 to 0.10 per cent.

2. Mild Steel. The steel contains more than 0.10 per cent of carbon, but is a very low carbon steel. The luminous streaks of the iron sparks, indicated by the wide black areas, fork or divide. The carbon content of the iron sparks is burned with explosive violence and breaks away from them.

3. Tool steel of lower carbon content, from 0.10 to 1.00 per cent carbon. The broad, luminous iron lines are less frequent. There is more forking and the forks are often subdivided.

4. The sparks from high carbon steel of the higher grades show practically no iron lines. Forks are very frequent and there are many star-like explosions dividing and subdividing the sparks.

5. High speed steel, containing chromium and tungsten, sparks in quite a different manner. The particles follow a broken or dotted line, as indicated, and just before they disappear the color is chrome yellow, showing no trace of a carbon spark.

6. The manganese spark is clearly indicated. It is quite different from the carbon spark, as will be noted. It appears to shoot out or explode at right angles to its line of travel.

7. Mushett steel is an old high speed steel containing sixteen or seventeen per cent of tungsten, two per cent of carbon and two per cent of manganese. This steel is found among old tools in old established factories and is not a modern high speed steel. There is no carbon spark and only an occasional manganese spark. The lines are broken and the sparks are very dark red.

8. Magnet steel. This sketch shows a steel used in the manufacture of magnets. This, as will be seen, produces an entirely different spark which can be easily distinguished from any of the others.
Information Unit VIII

Metals Commonly Forged or Welded. Smith (20)

Carbon Steel. This is a steel containing from 0.65% to 1.30% carbon with small percentages of manganese and silicon. It is used for making chisels, punches, dies and other tools. It is also used for making machine parts. Carbon steel forge readily and can be hardened and tempered. Cutting tools made of carbon steel operate best at relatively low speeds. Many drills and reamers are made of this steel.

High-speed Steel. This material contains approximately 0.70% carbon, 18% tungsten, 4% chromium and 1% vanadium. It is a general purpose high-speed steel and is used principally for making machine cutters of various kinds as well as drills, reamers and taps. This material has the advantage of being easy to forge and harden and of retaining an edge even when heated to a high temperature.

Low-tungsten Tool Steel. This steel contains approximately 0.50% carbon, 2.0% tungsten, 1.75% chromium and a fraction of a per cent of manganese, silicon and vanadium. When properly tempered, it is hard and tough and, because it holds an edge well under severe use, it is used extensively for making punches, chisels and other cutting tools.

Cobalt High-speed Steel. Steels of this type contain from 4% to 10% cobalt, 0.75% carbon, 18.0% tungsten, 4.0% chromium, 1.0% molybdenum, 1.0% vanadium and a small fraction of a per cent of manganese and silicon. They are used to make tools which serve the same purposes as tools made from high-speed steel.

Stellite. This is an alloy of tungsten, chromium and cobalt. It is used in the form of tips welded to tough carbon or other alloy shanks or in the form of tips welded on bits held in a tool holder. Stellite is a very brittle material and is likely to chip if engaged suddenly or if the machine is stopped in the process of the cut. It holds its edge even when red hot and operated at very high speeds.
Information Unit IX

Medium Pressure Generators as explained by Plumley in his material (17:46-49):

In generators of this type the usual pressure at which the machine is set to operate is about twelve pounds. This pressure may be changed by the operator, but for most work it will be found satisfactory. The carbide feeding mechanism will operate very accurately; many are set to start at a pressure of nine and seven-eighths pounds and stop at a pressure of ten pounds. There is, however, a certain amount of after generation caused by the complete disintegration of the lumps of carbide which have been dropped into the water by the feeding mechanism. This increases the pressure somewhat after the feeding mechanism has stopped feeding carbide.

How Generators Operate: The main shaft of the machine, revolved by the spring motor, extends downward through a pipe to a cross member revolving directly under the feed plate of the machine which is in a fixed or stationary position. The cross member revolves a sweep, made of asbestos rope, which moves in a horizontal circle directly over the feed disc or plate. Carbide is placed in the hopper until the hopper is full. It flows out of the bottom of the hopper and comes to rest on the stationary feed plate. When the motor is started the sweep revolves and sweeps or forces off the feed plate a few lumps of carbide which fall down into the water. Acetylene is thus produced and the pressure within the machine increases until it overcomes the spring pressure against the diaphragm directly under the motor and stops the motor. As the pressure is decreased by consumption of the gas at the torch, the motor is again started and more carbide is swept off the stationary disc down into the water. This movement of the sweep and the feeding of the carbide are, therefore, automatically started and stopped by the opening or closing of the torch valve.
Diagrammatic Sectional View of an Acetylene Generator. The Interlocking Rods and Levers which Make It Impossible to Open the Carbide Filling Cap in the Top of the Generator Without Releasing the Blow-off Valve and Locking the Motor are not Shown. These are Required by the Underwriters' Laboratories upon Approved Machines and Prevent the Removal of the Carbide Filling Cap While there is Pressure Within the Machine. They also Prevent the Motor from Feeding Carbide into the Bottom of the Generator During Charging when there is No Water In It.
Flash Back Check and Filter: To the left of the generator (shown on the previous page) is shown the flash-back check and filter tank in section. The flash-back check is in reality a submerged check valve, or in other words a check valve under water, preventing the backward flow of oxygen and acetylene or of a flame into the generator. The small tank is filled with water to the proper level by removing the plug on the side and filling with water until the tank is filled to the opening, thus submerging the check valve as the water rises in the pipe leading to the generator to the same elevation as in the tank. It is always very important that this tank be filled with water to its proper level, because it is the main protection of the generator from a flash-back which might be caused in the pipe line to the torches.

In the upper part of the flash-back check and filter tank, there is shown a filter consisting of a perforated partition over which is placed a quantity of hair felt or mineral wool. The gas passes upward through this filter which to a large extent prevents moisture and lime particles from passing upward with the gas. The flash-back tank aside from operating as a flash-back check, also is essentially a scrubber for the gas, as it bubbles upward through the water. Washing of the gas in this manner is beneficial to it and assists in removing particles of sludge.

Blow Off Valves: Attached to the outlet pipe from the flash-back check and filter tank is a blow-off valve set to blow off at fifteen pounds per square inch. The outlet of this blow-off valve is connected by a blow-off pipe line upward through the roof, ending in a return bend. There is another blow-off attached to the generator near the upper part of the hopper which is also set to blow at fifteen pounds per square inch and is connected by a separate blow-off line to the outside air. The blow-off pipes attached to the outlets of these two valves must always extend to the outside air separately and must not be connected together. Both of these blow-offs are connected by a rod to an auxiliary cover plate over the carbide filling opening in the top of the generator. This rod and cover are a part of the interlocking devices, not shown in any illustration, ... which prevent the opening of the carbide filling cap without moving the cover to one side thus
automatically raising the seat of each of the blow-off valves. This general device releases the pressure within the machine and at the same time through a separate device locks the motor so that no carbide can be fed into the lower part of the generator. When this is accomplished, the sludge outlet may be opened to drain the sludge out of the generator and the water filling valve opened to admit fresh water after the sludge has been removed. Carbide may then be filled into the hopper, the top replaced and fastened into position, but before the machine can again be placed in operation it is necessary to move the auxiliary cover over the carbide filling opening which automatically closes the blow-off valves and disengages the motor lock.
OXYGEN AND ACETYLENE GASES

Information Unit X

Gases; How Produced: The following is taken from a publication by Plumley (17:27-31):

Oxygen: There are two principal processes for the commercial production of oxygen. One of these is the separation of air into oxygen and nitrogen by liquefying the air and the other is the separation of water into oxygen and hydrogen by the electrolysis of water, or in other words, by passing an electric current through it. By far the greater proportion of the oxygen which is consumed in the United States is manufactured from air by the liquefaction process, and for this reason, a short description of this process will be given.

Liquefaction Process: A modern plant for producing oxygen by this process consists of air purifying towers, an air compressor and coolers, a drying battery and filter, a liquefaction column, a gas meter, a gas holder, an oxygen compressor and a cylinder charging manifold. The air is drawn by the air compressor through the air purifying tower where it comes in contact with a caustic solution sprayed over baffling devices. It enters the air compressor where it is compressed, when the equipment is first started, to a pressure of about 3,000 pounds, depending somewhat upon the type of equipment in use, and cooled so that the heat of compression is eliminated. The air then enters the drying battery where moisture and traces of carbon dioxide are removed through absorption by the caustic potash contained in the dryers.

From the dryers it enters the liquefaction column which is the heart of the plant where the oxygen is separated from the nitrogen. The liquefaction column is a tower, well insulated from the outside air. Within this insulated tower is a long vertical copper cylinder enclosing a series of copper coils constituting a heat exchanger. The dry air, free of carbon dioxide and under a normal working pressure of about 1,000 pounds, passes downward through the spiral tubes which are in contact with rising, cold nitrogen gas, thus lowering the temperature of the air. It continues downward through the coil until finally the coil reaches the lower part of the copper cylinder where
it makes several turns submerged in liquid oxygen already produced. The coil then rises to a point about midway in the tower and there the air is expanded through a needle valve from a pressure of 1,000 pounds to approximately five pounds.

It has already delivered heat to the liquid oxygen through which the coil passes, and expansion still further reduces the temperature to a point where the air will liquefy. This liquid trickles down over a series of baffle plates and the separation of oxygen from the nitrogen takes place for the following reasons:

At the pressure within the machine, oxygen will liquefy at approximately 295 degrees Fahrenheit below zero. Nitrogen, on the other hand, will not liquefy until the temperature is 317 degrees below zero. There is, therefore, a difference between the liquefaction temperatures of these two gases of about twenty-two degrees.

Therefore, when the spray of liquid air passes downward from the expansion valve, the nitrogen reverts back to the gaseous form more quickly than the oxygen and as it is lighter, rises to the top of the apparatus whereas the oxygen still in liquid form precipitates to the bottom. The action can be likened to the rising of steam from a teakettle on a stove. Water still remains in the kettle, while the steam rises from it as the water boils. The liquid oxygen collects in a reservoir at the bottom of the column and rises through a set of coils where it is changed to gas form by absorbing heat from the incoming air, circulating in separate coils closely in contact with those containing the oxygen. The oxygen in gas form finally leaves the top of the apparatus, passes through the meter and out to the gas holder. The nitrogen is allowed to escape to the outside air as it is not used under normal conditions. The oxygen compressor draws oxygen from the gas holder and compresses it in oxygen cylinders to a pressure of 2,000 pounds per square inch.

Calcium Carbide Produces Acetylene: Lumps of calcium carbide when dropped into water will disintegrate and produce a gas which is known as acetylene. This gas bubbles up to the surface of the water and leaves a residue in the water which consists principally of slaked lime. One pound of carbide will yield from four and one-half to five cubic feet of acetylene.
The production of acetylene from carbide requires a machine called an acetylene generator. Generators are used extensively all over the country for producing acetylene for welding and cutting. In fact the subject is so important that an entire lesson will be devoted to it to enable the student to learn how they are constructed, how operated and how the acetylene is distributed through pipe lines from them to the welding and cutting stations where the torches are connected.

Information unit IX, dealing with acetylene generators, gives a very detailed treatment of the operation of the machine mentioned above.

On the following page are sectional views of oxygen and acetylene cylinders.
1 volume of acetylene combines with 2½ volumes of oxygen and burns to form water vapor.

2 volumes of carbon dioxide and 1 volume of oxygen combine to form 3½ volumes of water vapor.

1 volume of acetylene combines with 1 volume of oxygen and burns to form carbon monoxide and 1 volume of hydrogen.

1 volume of hydrogen combines with oxygen from the air and burns to form 1 volume of water vapor.

2 volumes of carbon monoxide combine with oxygen from the air and burn to form 2 volumes of carbon dioxide.

Sketch Showing the Luminous Cone and the Envelope of Flame Produced by a Torch. The Chemical Reactions of the Flame and the Great Variation in the Temperature Developed in the Envelope Are Indicated.

Sectional View of an Acetylene Cylinder, Directly Under the Cylinder Valve a Hole Has Been Drilled in the Porous Filler and Subsequently Filled with Asbestos. This is to Facilitate the Discharge of the Acetylene from the Porous Filler to the Valve. This is a Typical Seamless, Drawn Cylinder of What is Known as the Monolithic Type.
Twelve Steps in Setting Up Welding Equipment

This is a view of the oxygen and the acetylene cylinders with the valve protecting caps in place. The oxygen cylinder has been placed to the right of the acetylene cylinder and close to it so that a clamp could be put in place fastening the two cylinders together to prevent tipping over.

Attaching the regulators. Both oxygen and acetylene regulators are attached respectively to the cylinder valve outlet nipples of the two cylinders. To prevent attaching the wrong regulator to the cylinder, the threads on these regulator nuts differ. Be sure that these threads are not crossed and that the regulator inlet nipples are firmly in place in the outlet nipples of the cylinder valves. Screw up the regulator connecting nut with a wrench until the union is gas tight.

Blowing out the regulators. Both adjusting screws are fully released by turning them to the left until there is no pressure upon the regulator spring within the bunnet. Cylinder valves are then slowly opened permitting the gases to enter the regulators. A slight turn to the right of each regulator adjusting screw will then slightly open the regulator valve or seat and permit the escape of the gases through the outlet nipples of the regulators. The adjusting screws are then again released.

Attaching hose. Both oxygen and acetylene hose lines are now attached to the outlet nipples of the regulators. The oxygen hose nut has a right hand thread and the acetylene hose nut has a left hand thread to prevent their being interchanged. Both are distinctly marked and need not be confused.

Opening the cylinder valves. Both oxygen and acetylene cylinder valves should be opened slightly and then quickly closed. This will blow out any dirt or grit which may have accumulated in the cylinder valve outlet nipples. Opening the valves in this manner before the regulators are put in place assures that the second time they are opened they will turn more easily and may be opened slowly.

Removing the caps. Sometimes the caps stick in place and a wrench must be used to remove them. Often tapping slightly on the threads will assist.
Blowing out hose. It is essential that no grit or dirt be allowed to remain in the hose and blown into the torch. Therefore, before the torch is attached it is good practice to blow out each line of hose by turning the regulator adjusting screws to the right until gas escapes from the end of the hose. Turn them to the left again when just enough gas has escaped to serve the purpose. Remember acetylene is inflammable and must not be allowed to catch fire.

Attaching the torch handle. The oxygen hose connecting nut is attached to the oxygen inlet of the torch and the acetylene hose connecting nut to the acetylene inlet of the torch. The oxygen hose nut is right handed and the acetylene hose nut left handed and, therefore, will not screw upon the wrong nipple. See that the joints are tight and that both torch valves are closed.

Blowing out the torch handle. This removes any grit or dirt in the passages. Open but one valve at a time. Both torch valves should not be opened at the same time until the torch is lighted.

Attaching tips. A tip of the proper size is screwed into the torch handle until it is tightly in position and the operator is sure that all joints will not leak gas.

Testing joints with soap and water. When the operator first sets up equipment and until he is sure that all connections are gas tight, it is good practice to test each joint with soap suds. With a small brush the soap and water are worked into a lather and this lather applied to each joint. Escaping gas will immediately show a soap bubble.

Lighting the torch. After regulators have been set at suitable pressures for the tip in use, as described in Job Sheet No. 1, the torch is lighted with a spark lighter.
Types of Flames: Plumley (17:6-15):

"A" is the neutral or balanced flame which is used in almost all instances for the welding of steel and for general purposes. It is the correct flame which will neither oxidize nor carbonize the metal. "B" is a carbonizing flame to which too much acetylene has been supplied. Besides the luminous cone and the secondary envelope of burning gases normally in the neutral flame, there is an additional green tinge of flame extending from the luminous cone indicating too much acetylene. By cutting down the acetylene supply with the acetylene torch valve, this green flame can be caused to disappear entirely, resulting in the neutral flame shown at "A". "C" is an oxidizing flame. The luminous cone is much shorter and is less luminous. The oxidizing flame is caused by too much oxygen. The envelope of the flame becomes a deeper purple and is very much shorter. The oxidizing flame "C" is caused by delivering too much oxygen and too little acetylene through the torch. This may be the result of improper setting of the pressures at the regulators or improper adjusting of the torch valves. An oxidizing flame will burn the weld and the adjacent metal and cause a porous and oxidized weld which is lacking in strength.

The carbonizing flame "B" on the other hand is caused by the delivery of too much acetylene through the torch. The carbon contained in this excess of acetylene contacts with the hot metal and makes it mottled or pitted in appearance and brittle. The carbonizing flame is used in some instances for certain classes of work, but it should only be used when it is known that the effect of an excess of acetylene is beneficial. Neither the carbonizing flame "B" nor the oxidizing flame "C" are used under any circumstances in the welding of cast iron or steel. For this class of work the correct flame is the neutral or balanced flame "A".

Pressures: Various tables of pressures for torches, either welding or cutting, are given on the following pages. The tables are prepared for use with Smith or Oxweld equipment, the Oxweld pressure tables are so labeled.
Sketch illustrating Neutral, Carbonizing and Oxidizing Flames and the Effect of Each upon a Steel Plate.
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 Av. Flame in Inches</th>
<th>Approximate Pressure at Regulator in Pounds per Square Inch</th>
<th>Main Port Drill Size</th>
<th>Dia. of Main Port in Inches</th>
<th>Approximate Cu. Ft. of Gas Used per Hour</th>
<th>Approx. Number of Linear Feet Welded per Hour</th>
<th>Size of Tip Assembly</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1/8</td>
<td>1/8</td>
<td>1</td>
<td>1</td>
<td>63</td>
<td>0.37</td>
<td>5.0</td>
<td>13.0</td>
</tr>
<tr>
<td>2</td>
<td>1/4 to 1/8</td>
<td>1/4</td>
<td>2</td>
<td>2</td>
<td>58</td>
<td>0.42</td>
<td>6.0</td>
<td>18.5—5.8</td>
</tr>
<tr>
<td>3</td>
<td>3/8 to 1/4</td>
<td>3/8</td>
<td>3</td>
<td>3</td>
<td>54</td>
<td>0.55</td>
<td>9.0</td>
<td>12.0—3.0</td>
</tr>
<tr>
<td>4</td>
<td>1/2 to 3/8</td>
<td>1/2</td>
<td>4</td>
<td>4</td>
<td>52</td>
<td>0.635</td>
<td>12.0—12.0</td>
<td>10.2—3.5</td>
</tr>
<tr>
<td>5</td>
<td>5/16 to 1/2</td>
<td>5/16</td>
<td>5</td>
<td>5</td>
<td>48</td>
<td>0.076</td>
<td>21.0—21.0</td>
<td>8.3—7.5</td>
</tr>
<tr>
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<td>3/16 to 3/8</td>
<td>3/16</td>
<td>6</td>
<td>6</td>
<td>44</td>
<td>0.086</td>
<td>23.0—23.0</td>
<td>4.2—2.3</td>
</tr>
<tr>
<td>7</td>
<td>1/4 to 5/16</td>
<td>1/4</td>
<td>7</td>
<td>7</td>
<td>40</td>
<td>0.098</td>
<td>36.0—36.0</td>
<td>3.1—2.0</td>
</tr>
<tr>
<td>8</td>
<td>1 and over</td>
<td>1/8</td>
<td>8</td>
<td>8</td>
<td>32</td>
<td>0.116</td>
<td>58.0—58.0</td>
<td>2.1—1.7</td>
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<td>Heavy</td>
<td>3/8</td>
<td>9</td>
<td>9</td>
<td>28</td>
<td>0.1405</td>
<td>100.0—100.0</td>
<td>Variable</td>
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<td>10</td>
<td>Castings</td>
<td>4/8</td>
<td>10</td>
<td>10</td>
<td>26</td>
<td>0.147</td>
<td>106.0—106.0</td>
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<tr>
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<td>Etc.</td>
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<td>11</td>
<td>25</td>
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**FLANGED EDGE FOR SHEETS 1/32 INCH AND UNDER IN THICKNESS**

**STRAIGHT EDGE FOR PIECES NOT EXCEEDING 3/8 INCH**

**SINGLE VEE EDGE FOR PIECES 3/16 INCH AND OVER**

**CIRCULAR VEE FOR VERY HEAVY CASTINGS**

**SKETCH SHOWING THE AVERAGE SIZE OF FLAME FOR EACH SIZE OF TIP**

This Chart Shows the Average Size Flame Produced by Each Tip When the Regulators Are Set at the Pressures Given. It Also Gives the Drill Sizes and the Diameters of the Various Sizes of Tips, the Method for Preparing Various Thicknesses of Metal, the Average Speed of Welding and the Approximate Consumption of Oxygen and Acetylene of Each Size of Tip.
Approximate Cutting Table Showing Thickness of Steel, Size of Tip, Oxygen and Acetylene Pressures and Speed of Cutting

<table>
<thead>
<tr>
<th>Thickness of Steel in Inches</th>
<th>Number of Tip</th>
<th>Drill Size of Oxygen Cutting</th>
<th>Oxygen Pressure Lbs. Per Sq. Inch</th>
<th>Acetylene Pressure Lbs. Per Sq. Inch</th>
<th>Cutting Speed Inches Per Minute</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/8</td>
<td>1-4</td>
<td>56</td>
<td>10-15</td>
<td>3</td>
<td>18-20</td>
</tr>
<tr>
<td>1/2</td>
<td>2-4</td>
<td>54</td>
<td>15-20</td>
<td>3/4</td>
<td>15-18</td>
</tr>
<tr>
<td>1</td>
<td>3-4</td>
<td>52</td>
<td>20-25</td>
<td>4</td>
<td>10-12</td>
</tr>
<tr>
<td>3</td>
<td>4-4</td>
<td>48</td>
<td>25-30</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>5-4</td>
<td>43</td>
<td>30-35</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>6</td>
<td>6-4</td>
<td>38</td>
<td>45-50</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>8</td>
<td>6-4</td>
<td>38</td>
<td>65-75</td>
<td>5</td>
<td>3</td>
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</tbody>
</table>

Table Showing the Consumption of Oxygen and Acetylene in Cubic Feet in the Preheating Flames of the Cutting Tip

<table>
<thead>
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<th></th>
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<td>17</td>
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<td>3-4</td>
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<td>28</td>
<td>28</td>
</tr>
<tr>
<td>4-4</td>
<td>5</td>
<td>5</td>
<td>38</td>
<td>38</td>
</tr>
<tr>
<td>5-4</td>
<td>5</td>
<td>5</td>
<td>54</td>
<td>54</td>
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Sizes and Data for Tube Turns Manufactured by, TUBE TURNS, INC., Louisville, Ky.

Standard Thickness—IRON PIPE SIZES—Series 1 1/2 R

<table>
<thead>
<tr>
<th>Nominal Pipe Size</th>
<th>Radius of Tube Thickness</th>
<th>Pipe Diameter</th>
<th>Wall Thickness</th>
<th>Pressure</th>
<th>Weight (Lbs/Bursting Pounds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3'</td>
<td>11.2</td>
<td>1.085</td>
<td>.028</td>
<td>11.05</td>
<td>17.520</td>
</tr>
<tr>
<td>1'</td>
<td>11.2</td>
<td>1.105</td>
<td>.033</td>
<td>11.15</td>
<td>16.000</td>
</tr>
<tr>
<td>1 1/2</td>
<td>11.2</td>
<td>1.105</td>
<td>.033</td>
<td>11.15</td>
<td>16.000</td>
</tr>
<tr>
<td>2'</td>
<td>11.2</td>
<td>1.105</td>
<td>.033</td>
<td>11.15</td>
<td>16.000</td>
</tr>
<tr>
<td>2 1/2</td>
<td>11.2</td>
<td>1.105</td>
<td>.033</td>
<td>11.15</td>
<td>16.000</td>
</tr>
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<td>.033</td>
<td>11.15</td>
<td>16.000</td>
</tr>
<tr>
<td>4'</td>
<td>11.2</td>
<td>1.105</td>
<td>.033</td>
<td>11.15</td>
<td>16.000</td>
</tr>
<tr>
<td>5'</td>
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<td>11.15</td>
<td>16.000</td>
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<tr>
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<td>1.105</td>
<td>.033</td>
<td>11.15</td>
<td>16.000</td>
</tr>
<tr>
<td>8'</td>
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<td>.033</td>
<td>11.15</td>
<td>16.000</td>
</tr>
<tr>
<td>10'</td>
<td>11.2</td>
<td>1.105</td>
<td>.033</td>
<td>11.15</td>
<td>16.000</td>
</tr>
<tr>
<td>12'</td>
<td>11.2</td>
<td>1.105</td>
<td>.033</td>
<td>11.15</td>
<td>16.000</td>
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</table>

Extra Heavy—IRON PIPE SIZES—Series 1 1/2 Rx

<table>
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<tr>
<th>Nominal Pipe Size</th>
<th>Radius of Tube Thickness</th>
<th>Pipe Diameter</th>
<th>Wall Thickness</th>
<th>Pressure</th>
<th>Weight (Lbs/Bursting Pounds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3'</td>
<td>11.2</td>
<td>1.085</td>
<td>.028</td>
<td>11.05</td>
<td>17.520</td>
</tr>
<tr>
<td>1'</td>
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<td>1.105</td>
<td>.033</td>
<td>11.15</td>
<td>16.000</td>
</tr>
<tr>
<td>1 1/2</td>
<td>11.2</td>
<td>1.105</td>
<td>.033</td>
<td>11.15</td>
<td>16.000</td>
</tr>
<tr>
<td>2'</td>
<td>11.2</td>
<td>1.105</td>
<td>.033</td>
<td>11.15</td>
<td>16.000</td>
</tr>
<tr>
<td>2 1/2</td>
<td>11.2</td>
<td>1.105</td>
<td>.033</td>
<td>11.15</td>
<td>16.000</td>
</tr>
<tr>
<td>3'</td>
<td>11.2</td>
<td>1.105</td>
<td>.033</td>
<td>11.15</td>
<td>16.000</td>
</tr>
<tr>
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<td>11.2</td>
<td>1.105</td>
<td>.033</td>
<td>11.15</td>
<td>16.000</td>
</tr>
<tr>
<td>5'</td>
<td>11.2</td>
<td>1.105</td>
<td>.033</td>
<td>11.15</td>
<td>16.000</td>
</tr>
<tr>
<td>6'</td>
<td>11.2</td>
<td>1.105</td>
<td>.033</td>
<td>11.15</td>
<td>16.000</td>
</tr>
<tr>
<td>8'</td>
<td>11.2</td>
<td>1.105</td>
<td>.033</td>
<td>11.15</td>
<td>16.000</td>
</tr>
<tr>
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<td>11.2</td>
<td>1.105</td>
<td>.033</td>
<td>11.15</td>
<td>16.000</td>
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<tr>
<td>12'</td>
<td>11.2</td>
<td>1.105</td>
<td>.033</td>
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<td>16.000</td>
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<tr>
<td>14' OD</td>
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<td>20' OD</td>
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</table>

All stock sizes furnished with ends beveled 45 degrees for welding unless otherwise specified.
### PRESSURE TABLE FOR OXWELD WELDING BLOWPIPES (TORCHES)

<table>
<thead>
<tr>
<th>Thickness of Metal</th>
<th>Types W-1, W-10, W-11, W-14</th>
<th>Types W-15, W-17, W-22</th>
</tr>
</thead>
<tbody>
<tr>
<td>32</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>28</td>
<td>1</td>
<td>2</td>
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<tr>
<td>25</td>
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<td>3</td>
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<tr>
<td>22</td>
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<td>4</td>
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<td>14</td>
<td>15</td>
</tr>
<tr>
<td>1 and over</td>
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<td>16</td>
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<td>21</td>
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### PRESSURE TABLE FOR OXWELD CUTTING BLOWPIPES (TORCHES)

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</tr>
<tr>
<td>30</td>
<td>No. 2</td>
<td>No. 6</td>
<td>17-24</td>
</tr>
<tr>
<td>35</td>
<td></td>
<td>20-28</td>
<td></td>
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<td>40</td>
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<td>24-34</td>
<td></td>
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<td>45</td>
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<td>28-40</td>
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<td>10</td>
<td>75-91</td>
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<td>69-80</td>
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<tr>
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### TIME FOR CUTTING STEEL WITH OXWELD BLOWPIPES (TORCHES)

<table>
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<th>Thickness of Metal in Inches</th>
<th>Linear Cutting Speed</th>
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<td></td>
<td>Machine Cutting In. Per Minute</td>
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<tr>
<td>3/4</td>
<td>23-32</td>
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<tr>
<td>1/2</td>
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</tr>
<tr>
<td>3/8</td>
<td>19-26</td>
</tr>
<tr>
<td>1/4</td>
<td>18-25</td>
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<tr>
<td>3/16</td>
<td>15-22</td>
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<tr>
<td>1/8</td>
<td>14-19</td>
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<td>3/32</td>
<td>10-14</td>
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<tr>
<td>1/4</td>
<td>9-11</td>
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<td>3/16</td>
<td>6-9</td>
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<td>1/8</td>
<td>5-7</td>
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<tr>
<td>3/32</td>
<td>5-6</td>
</tr>
<tr>
<td>1/4</td>
<td>4-5</td>
</tr>
<tr>
<td>3/16</td>
<td>3-4</td>
</tr>
<tr>
<td>1/8</td>
<td>2-3</td>
</tr>
</tbody>
</table>
Information Unit XIII

1. Studying Informational Units. One should study very carefully all of the informational material given in each unit. The conditions, objectives, instructions, methods, descriptions, and the drawings, figures and tables should receive one's careful consideration. New materials or information should be, whenever possible, correlated with old materials. That is, the materials previously studied should be reviewed preparatory to beginning the new unit of study. A complete understanding of informational materials of each unit is quite necessary in order to realize fully the values of the related operational materials.

2. Studying Operational Units. Operational units when carried out manually reveal one's understanding of the informational units of study. They are tests, to a very marked degree, of a person's preparation for an operation. If a proper understanding of the unit data and procedures has not been developed, only mediocre or poor results may be expected in an operation, be it cutting a bevel with the torch or welding a lap joint or any of the many operations an efficient welder must be able to perform.

A very careful study of all instructions and plans
related to the operation or operations is quite essential. In studying the job or exercise, one should become familiar with all specifications, points of trouble, expansion and stress problems, etc. A plan of procedure is always recommended as good practice -- a step by step plan of the work from start to finish. A thorough knowledge of the informational and operational materials is the first prerequisite for the operation or exercise.

A complete and thorough knowledge of the problem at hand saves time, costs, and trouble. It is well to remember that the "mis" in mis-understand is also the "mis" in mistake.

3. Reading a Welding Plan. In order to simplify matters and to develop a uniform understanding among persons associated with welding processes, certain symbols have been adopted for welding plans or drawings. These symbols are easily incorporated into a drawing. They provide a means of imparting to the welder certain instructions as to what to do and how to do a particular weld or type of weld. To be able to read and understand a welding plan, one must become familiar with the figures and symbols given on page 98.

4. Sketching a Welding Plan. Good practice in developing familiarity with and knowledge of welding symbols is welding plan sketching in which only symbols are used to
designate kinds and types of welds to be used. The sketches may then be checked against the symbols shown on page 98 for completeness and correctness. One should sketch the course exercises and incorporate into them the proper symbols for the welds to be studied.

5. **Making a Bill of Material.** A stock record card or bill of material is necessary for each exercise or job in order to show the size, kind, and amount of materials used. The record should include the name or description of the job or operation, size or sizes of tips used, amount of time for welding, amount of oxygen and acetylene used, total amount of time on the job, operator’s name, date, and the total cost of all materials used.

The following is a suggested procedure to use in making out a bill of material:

**Procedure.** Smith (20;9)

1. Enter each article or group of articles on the stock card.

2. Total the amount of materials in each item.

3. From the price list or from your instructor, secure the cost per unit of each item, that is, the cost per pound, per square foot, or the cost of a single article.

4. Compute the cost of each item and enter it in the appropriate column on the stock card.

5. Calculate the total cost and enter it in the space provided on the stock card.

The job or exercise should be studied carefully in order to determine exactly the materials, etc., needed.

Good practice is to make out the cards in duplicate, one
FUSION WELDING SYMBOLS

<table>
<thead>
<tr>
<th>TYPE OF WELD</th>
<th>BEAD</th>
<th>FILLET</th>
<th>GROOVE</th>
<th>PLUG &amp; SLOT</th>
<th>FIELD WELD</th>
<th>WELD ALL AROUND</th>
<th>FLUSH</th>
</tr>
</thead>
<tbody>
<tr>
<td>SQUARE</td>
<td>V</td>
<td>U</td>
<td>J</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NEAR WELD

- FIELD WELD
- SEENOTE B
- SIZE
- FLUSH
- ROOT OPENING

FAR WELD

- INCLUDED ANGLE
- SIZE
- B2
- ROOT OPENING
- SIZE
- WILL-
- ALL AROUND
- OFFSET IF STAGGERED
- PITCH OF INCREMENTS

NEAR AND FAR WELDS

NOTE: Relative position of data and symbols shown.
Near and far significance as given in instructions.

**Fig. 1** Legend for use on drawings specifying fusion welding.

1. Welds parallel to the plane of the paper or nearly so, with faces toward reader are near welds, those with faces away from reader are far welds.
2. Welds in section or end views with faces toward the arrow are near welds, those with faces away from the arrow are far welds.
3. In joints in which one member only is to be grooved, arrow points to that member.
4. Welds on both sides are same size unless otherwise shown.

NOTE: All Dimensions are in Inches

**NOMENCLATURE OF WELDS**

**Fig. 2** Standard location for information on welding symbols.

5. Symbols apply between abrupt changes in direction of weld or as dimensioned.
6. All welds are continuous and of user's standard proportions and all except V- and bevel-grooved welds are closed unless otherwise shown.
7. Tail of arrow used for specification reference.
to be retained by the operator and the other for the instructor's files.

6. **Estimating Costs.** Experience gained by making out bills of material will aid materially in developing a person's understanding in estimating costs of projects. After some knowledge and experience has been developed in dealing with costs, an individual should make it a practice to analyze the plans and specifications for a project or operation and mentally estimate the total cost or the unit costs if the project is quite large. The estimates should be recorded and finally checked against the true costs as determined by the computed bill of materials. This policy of estimating the costs first and then checking them against the true costs will develop the learner's understanding and appreciation of economic values.
### Information-operation Unit XIV

<table>
<thead>
<tr>
<th>Size</th>
<th>Weight</th>
<th>Price lb.</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. 1(\frac{1}{2})^&quot; x 1&quot; x 96&quot;</td>
<td>10 lbs.</td>
<td>8 ¢</td>
<td>?</td>
</tr>
<tr>
<td>2. 1(\frac{1}{2})^&quot; x 1&quot; x 96&quot;</td>
<td>20 lbs.</td>
<td>8 ¢</td>
<td>?</td>
</tr>
<tr>
<td>3. 1(\frac{1}{2})^&quot; x 1&quot; x 96&quot;</td>
<td>18 lbs.</td>
<td>8(\frac{2}{5}) ¢</td>
<td>?</td>
</tr>
<tr>
<td>4. 1(\frac{1}{2})^&quot; x 1&quot; x 96&quot;</td>
<td>15 lbs.</td>
<td>8(\frac{3}{4}) ¢</td>
<td>?</td>
</tr>
<tr>
<td>5. 12&quot; x 12&quot; x (\frac{1}{4})^&quot;</td>
<td>10 lbs.</td>
<td>9(\frac{1}{2}) ¢</td>
<td>?</td>
</tr>
<tr>
<td>6. (\frac{1}{2})^&quot; x 1&quot; x 12&quot;</td>
<td>.42 lb.</td>
<td>8 ¢</td>
<td>?</td>
</tr>
<tr>
<td>7. 1&quot; x 1&quot; x 12&quot;</td>
<td>.84 lb.</td>
<td>8 ¢</td>
<td>?</td>
</tr>
<tr>
<td>8. 2&quot; x 1&quot; x 12&quot;</td>
<td>page 75</td>
<td>8 ¢</td>
<td>?</td>
</tr>
<tr>
<td>9. 3&quot; x 1&quot; x 12&quot;</td>
<td>page 75</td>
<td>8 ¢</td>
<td>?</td>
</tr>
<tr>
<td>10. 4&quot; x 1&quot; x 12&quot;</td>
<td>page 75</td>
<td>8(\frac{3}{4}) ¢</td>
<td>?</td>
</tr>
<tr>
<td>12. 5&quot; x 1&quot; x 12&quot;</td>
<td>page 75</td>
<td>9 ¢</td>
<td>?</td>
</tr>
<tr>
<td>13. 1&quot; x 1&quot; x 18&quot;</td>
<td>page 75</td>
<td>8 ¢</td>
<td>?</td>
</tr>
<tr>
<td>15. 1&quot; x 1&quot; x 30&quot;</td>
<td>page 75</td>
<td>8 ø</td>
<td>?</td>
</tr>
<tr>
<td>16. (\frac{1}{2})^&quot; x 1&quot; x 12&quot;</td>
<td>page 76</td>
<td>8 ø</td>
<td>?</td>
</tr>
<tr>
<td>17. (\frac{1}{2})^&quot; x 1&quot; x 6&quot;</td>
<td>page 76</td>
<td>8 ø</td>
<td>?</td>
</tr>
<tr>
<td>18. (\frac{1}{2})^&quot; x 1&quot; x 18&quot;</td>
<td>page 76</td>
<td>8(\frac{2}{5}) ø</td>
<td>?</td>
</tr>
<tr>
<td>19. 1&quot; x 1&quot; x 20&quot;</td>
<td>page 76</td>
<td>9 ø</td>
<td>?</td>
</tr>
<tr>
<td>20. 2&quot; x 2&quot; x 17&quot;</td>
<td>page 76</td>
<td>9(\frac{3}{4}) ø</td>
<td>?</td>
</tr>
</tbody>
</table>

It is good practice to calculate costs of materials of random sizes and lengths as found in a stockroom.
1. Getting Out Stock. After the bill of materials has been made, the stock may be procured. Short pieces, "shorts" as they are commonly known, are odds and ends that remain from longer materials. They should be used whenever possible. The use of shorts makes for economy and reduces waste to a minimum. The student should become well acquainted with the different kinds of stock and the different locations of each so that no mistakes will be made in the selection or in the replacement of unused stock. Care should be exercised in handling long pieces of stock in order to avoid injury to fellow-students, and to overcome damage to the stock itself. Only the necessary amount of stock should be removed from the racks or containers, and unused materials should always be properly replaced. Each piece of stock removed from the racks should be accounted for in the bill of material.

2. Laying Out Stock. After the required amount of stock has been selected, the problem is to lay it out according to specifications or instructions. This operation requires the use of various tools. A square or a similar tool for measuring is required as well as a tool, such as a scriber, for marking off lines. Quite often a center
punch is used to mark location points for lines, cuts, holes, bends, etc. Each measurement should be taken carefully and identified with a suitable mark -- a light line or punch mark. Measurements should be retaken for a double-check. If all prove to be correct and accurate, final and heavier marks may be made. After all stock has been measured and laid out, it is advisable to check the pieces and measurements against the bill of materials and the specifications or plans. This policy tends to overcome errors and mistakes in the amount and the lay-out of the stock.

3. Preparing the Stock. The job of preparing the stock for welding is of major importance. Each piece of material should be cut carefully and checked for accuracy. Notches, bevels, shoulders, etc. should all be tested for accuracy and fit. If it is necessary to file or grind for a joint, the operator should make frequent checks or tests. Stock may be prepared for welding by such operations as sawing, filing, grinding, chiseling, cutting with the torch, etc., but whichever method is used care and accuracy should be paramount. If cuts are to be square, they should be laid out as such. After they are made they should be checked for squareness.

After the material has been prepared for welding, a set-up trial assembly should be made. If errors in the assembly are noted, corrections should be made before the
welding operation is undertaken. During the operation of welding, it will be necessary to consider the problem of expansion and warping. Whenever possible, final corrections should be made to compensate for these difficulties. In most cases it is quite imperative that corrections for squareness and proper fitting of parts be made while the welded portion is still in a very high degree of temperature. After a welded article has been corrected, it may vary somewhat in accuracy during the cooling process. Checks and corrections for such variations should be made.

Properly prepared stock will tend to overcome many difficulties, thus reducing the welding operation problems to a minimum. Time spent on preparing the materials is time and trouble saved in the final assembly operations.
HOW TO LIGHT A TORCH

Information Unit XVI

Operation Unit 14 (in part) by Smith (20:29)

Procedure

1. Connect the hose with the left-hand thread to the acetylene regulator and the right-hand one to the oxygen regulator, then screw the connection tight.

2. Select a welding tip of a size suitable for the work to be performed.

A good practice is to use a tip of the size recommended by the maker of the apparatus for a given type of work and metal; as for example, the tip recommended for welding 1/16" mild steel.

3. Mount the tip on the mixing head and adjust it to the angle desired for welding, then tighten the union by hand.

4. Open the valve on the acetylene cylinder about 1/2 full turns.

5. Slowly open the acetylene needle valve on the torch and turn (to the right) the acetylene regulator adjusting screw until the low pressure gauge registers the working pressure recommended by the manufacturer, then close the needle valve.

It is good practice to set the pressures at the regulators slightly higher than the recommended tip pressures, then make minor adjustments with the torch needle valve.

6. Open the valve on the oxygen cylinder and continue turning it until the top of the valve seat is drawn against the top of the valve chamber. This seals the chamber and prevents the escape of oxygen.

7. Open the oxygen needle valve on the torch and adjust the oxygen regulator by turning the adjusting screw to the right until the gauge registers the working pressure recommended, then close the needle valve. [italics in original quotation].
8. Hold the torch in the left hand with the nose of the tip pointed away from the body and away from the cylinder; then open the acetylene needle valve and the oxygen valve slightly; then ignite the gas with a sparklighter, . . . [italics in original quotation].

9. Continue opening the oxygen needle valve slowly and adjust it until a neutral flame is produced.
Oxyacetylene cutting is the process of burning metal with oxygen to effect separation or form shapes of various kinds. At present, apparatus has been developed only for cutting wrought iron, mild steel, stainless steel and cast iron. In this process the metal is heated with preheating flames, usually four, emerging through openings equally spaced around a central opening in the center of the cutting tip.

The central opening supplies the oxygen which ignites the previously heated metal and causes it to burn away rapidly in the form of iron oxide. The path cut through the metal resembles that cut by a saw in a piece of wood except that it is wider and perhaps a little more irregular.

For cutting metals up to 3" or 4" thick, the same apparatus as used for welding may be employed with the exception of the cutting tip. The principal difference between a welding and a cutting torch is that the flame in the latter is divided into small jets surrounding the opening in the center of the tip. The central opening supplies the oxygen which produces the cutting action. The flow of oxygen is controlled by an independent valve. Oxygen and acetylene are mixed in a mixing chamber and delivered through the outer holes in the tip to supply the preheating flames.

A special oxygen cutting pressure regulator is recommended for oxyacetylene cutting and is an absolute necessity for cutting metal thicker than 4".

Some torches are provided with guide wheels which may be attached to the nozzle with set screws. So equipped, the tip is held at a constant distance from the face of the work. For cutting rectangles, circles and irregular shapes, a mechanical device is used which directs the course of the flame. The procedure for cutting carbon steel, wrought iron and cast is described below. A different technique and much higher preheating temperatures and pressures are required for cutting cast iron and some alloy steels. Moderate preheating is recommended when cutting high-carbon steel and alloy steels. After cut-
ting, anneal to relieve internal strains.

Oxyacetylene cutting is becoming a very important procedure in the art of metalworking. Its very rapid cutting action and extreme flexibility permit of its use in cutting or shaping complicated, irregular shapes or of flame machining work with great accuracy.

Procedure

**MILD STEEL**

1. With a stiff wire brush or a scraper, remove any scale, dirt or paint on the surface of the metal. Scale and foreign matter retard the cutting action and waste oxygen.

2. Put on goggles and welding clothing.

3. With a piece of soapstone, lay out the line on which the cut is to be made.

4. Attach the cutting torch or tip, being sure that all connections are tight and correctly made.

5. Light the torch. Follow the same procedure and exercise the same precautions as when lighting the torch for welding.

6. Adjust the acetylene and oxygen regulators to the pressures recommended by the manufacturer of the torch.

7. Adjust the oxygen needle valve until a neutral flame is achieved. See step 9. Operation Unit 14.

8. Open the oxygen cutting valve by depressing the trigger or lever, ..., and observe the effect on the preheating flames. If these are changed, readjust the oxygen needle valve until the preheating flames are neutral when the cutting oxygen valve is open.

9. Hold the torch with the nozzle perpendicular to the metal, then bring the tips of the inner cones of the preheating flame [italics in original quotation] nearly into contact (about 1/16" away) with the work at one end of the line, .... If possible, rest the forearm on a convenient support and with the free hand grasp the torch near the nozzle. This will
assist in guiding the nozzle along the line of cut.

10. When the metal is heated to a bright red, turn on the cutting jet by depressing the lever or trigger.

11. When the metal begins to burn and a groove is started, move the torch steadily along the line, being sure to hold the torch so that the tips of the inner cones of the preheating flames very nearly touch the surface of the work and the cutting jet follows the line. The rate at which the torch moves depends upon the thickness of the metal and the condition of the surface.

When cutting circles in the center of a plate or other enclosure, start the cut inside the circle or layout, then move outward and follow the outline.

When cutting on the outside of a circle, start at one edge of the stock, then move inward and follow the outline.

12. When through cutting:
   1. Release the oxygen trigger.
   2. Close the acetylene valve on the torch.
   3. Close the oxygen valve on the torch.
   4. Close the acetylene valve on the cylinder.
   5. Close the oxygen valve on the cylinder.
   6. Drain the hose lines in the usual manner.
   7. Close both needle valves and release the regulator pressure, adjusting screws by turning them to the left until the pressure is released.

CAST IRON

1. Adjust the oxygen regulator to give the pressure recommended.

2. Light the torch in the usual manner.

3. With the cutting valve open, adjust the heating flames so that there is an excess of acetylene. The acetylene feather produced should be slightly in excess of twice the length of the inner cone.

4. Close the oxygen cutting valve, then with the heating flame preheat the edge of the stock to a bright red.
5. Move the torch to the upper side of the work with the nozzle inclined to the rear at about 75°.

6. Hold the nozzle so that the tips of the inner cones are 1/8" to 3/16" above the metal, then move the flame back and forth across the line describing a series of small semicircles.

7. Continue these movements until an area 1/2" to 3/4" is heated to the point where the metal begins to boil.

8. Quickly move the nozzle off the heated area, then instantly open the oxygen cutting valve and move the nozzle over the line of cut with the nozzle inclined to the rear at an angle of about 45°.

9. Move the flame along the line of cut maintaining the semicircle movements described above. Be sure to maintain the oscillating movement throughout the cut.

10. As the cut advances, gradually straighten the torch until the nozzle is inclined at about 75°.

11. When the far edge is reached, carry the torch over the edge and down the side until the metal is completely severed.

12. When through cutting, shut off the acetylene and oxygen in the usual manner.
Cutting nozzle is oscillated.
Information-operation Unit XVIII

Shop Assignment 49 by Rossi (18/75-77)
DEPOSITING BEADS ON A FLAT SURFACE WITHOUT USING A FILLER ROD

Conditions: Position of Weld: Flat
Materials Used: Mild-steel sheet-metal strips; 1/16 to 1/8 in. in thickness.

Size of Welding Tip: No. 1.
Oxygen Pressure: 1 lb.
Acetylene Pressure: 1 lb.
Type of Flame: Neutral.
Size and Types of Filler Rod: None.
Flux: None.

Object: To develop a definite torch "feel" and a welding technique that best fits the individual operator.

Instructions. For good welding, it is essential that the welding flame be properly adjusted.

A neutral flame is one in which there is no excess of either oxygen or acetylene. It is produced when a 1-to-1 mixture of the two gases is lighted at the torch tip. The flame has two sharply defined zones. Inside the flame, next to the tip, there is a brilliant white cone about 1/16 to 3/4 in. in length. Surrounding this inner cone there is a larger cone, or envelope flame, that is only faintly luminous and that has a slight bluish color. A colorless cone is usually present between these two cones . . .

A carburizing flame is one in which there is an excess of acetylene in the mixture. The flame consists of three zones. As in the neutral flame, there is a sharply defined inner cone and a bluish outer envelope; but between these, surrounding the inner cone, there is an intermediate cone of whitish color. The length of this intermediate cone, produced by the excess acetylene, may be taken as a measure of the amount of excess acetylene in the flame . . .

An oxidizing flame is had when the oxygen is in excess in the mixture. The flame resembles a neutral flame; but the inner cone is shorter, it is
not sharply defined, and has a purplish tinge . . .

In order to produce clean and sound welds, a neutral flame should be maintained at all times. A carburizing flame will produce a boiling condition in the melted steel, and the finished bead will have a spongy appearance and a mass of surface holes. An oxidizing flame will produce a boiling, burning condition; the top of the bead will be covered with scale, with small pinholes underneath, and the steel in the neighborhood of the melted area will become very hard.

The speed of welding should be uniform and should be controlled by the speed of melting. If the movement of the torch is too slow, the plate becomes overheated; as a result, either the steel is burned, or a hole is burned through the steel.

The bead, when properly done, should be clean, smooth, and bright in color.

Procedure. a. The apparatus should be set up. The oxygen and acetylene pressures should be adjusted to the recommended values. The torch should be lighted and set for neutral flame. The work plates should be placed flat on the welding table.

b. The operator should practice making beads by holding the tip at approximately a 45-deg. angle and moving the flame forward only. As the surface of the steel starts to melt and to form a small puddle, care should be taken to move the torch forward only as fast as the steel melts on the surface.

The operator should vary the angularity of the tip to the work in order to develop the proper angle best suited to him.

Questions.

1. What is a neutral flame? What are its characteristics?
2. What is a carburizing flame? What are its characteristics?
3. What is an oxidizing flame? What are its characteristics?
4. What type of flame will produce clean and sound beads?
5. What is the effect of using a carburizing flame?
6. What is the effect of using an oxidizing flame?
7. What controls the speed of welding?
Forming bead in the flat position without use of filler rod.

Making corner weld with filler rod in the flat position.

Making butt weld on light-gauge sheet metal in the flat position.

Making corner weld in the flat position without filler rod.

Making single-Vee butt weld in the flat position.

Building up bosses of weld metal in the flat position.
Beaded with Filler Rod

Information-Operation Unit XIX

Shop Assignment 51 by Rossi (18:77-78)
DEPOSITING BEADS ON A FLAT SURFACE WITH FILLER ROD

Conditions. Position of Weld: Flat.
Materials Used: Mild-steel sheet-metal strips, 1/16 or 1/8 in., and 1/4 in. in thickness.
Size of Welding Tip: No. 2 and 5.
Oxygen Pressure: 21bs. for No. 2 welding tip; 5 lbs. for No. 5 welding tip.
Acetylene Pressure: 2 lbs. for No. 2 welding tip; 5 lbs. for No. 5 welding tip.
Type of Flame: Neutral.
Size and Type of Filler Rod: 1/16- or 3/32- in. and 3/16- in. diameter mild-steel filler rods.
Flux: None.

Object. To deposit beads on flat steel strips by using filler rod.

Instructions. In the filler-rodd technique, the point where the weld is to be started should be brought to a molten condition, but at the same time the tip of the filler rod should be held close to the area being heated. This makes it possible for the base metal and the filler rod to reach fusion point at the same instant, but care should be taken not to overheat. The bead should be built up no faster than both filler rod and base metal can be melted. When the filler rod sticks to the workpiece, it is a sign that either the rod is being moved along too fast or the workpiece and the rod are not being melted sufficiently to maintain the fusing action. In making the weld, the torch should be moved slowly from side to side to a width of 1/4 to 3/8 in.

The size of the filler rod to be used depends upon the required size of the weld. For light gauges, a 1/16- or 3/32- in. diameter filler rod may be used, but for the heavier sections a 3/16- in. diameter rod should be used. Of course, a small torch tip should be used with the smaller
filler rods, and a larger tip should be used with the larger filler rods.

Procedure. a. The apparatus should be set up, and the oxygen and acetylene pressures should be adjusted to the values recommended for the size of the welding tip used. The torch should be lighted and set for neutral flame. The work plates should be positioned flat on the welding table.

b. The operator should practice making beads 1/8 in. high on the light-gauge sheets by using 1/16- or 3/32-in. diameter filler rods and a No. 2 welding tip. The finished welds should be inspected for appearance and general characteristics.

c. The operator should practice making beads 1/4 in. high on heavy plates by using 3/16-in. diameter filler rods. The finished welds should be inspected for appearance and general characteristics.

Questions.

1. In bringing the point where the weld is to be started to a molten condition, how and where should the tip of the filler rod be held?

2. How fast should a bead be deposited?

3. What causes the sticking of the rod?

4. How should the torch be moved in depositing a bead on a flat surface?

5. What does the size of the filler rod to be used depend upon?
Testing of Welds by Harcourt (6:73-78)

The purpose of testing welds made with the oxy-acetylene welding torch is to compare the strength, ductility, etc. of the weld with the base metal, to determine the unit strength of the weld, or for examination of fracture through the weld metal.

A brief outline of the various methods that have been devised for testing welds follows; the tests used are divided into two groups, destructive and non-destructive.

**DESTRUCTIVE GROUP**
- Tensile Test
- Fatigue Test
- Bend Test
- Hardness Test
- Nick-Break Test
- Hot Acid Test
- Impact Tests
- Etching Test

**TENSILE TEST**

Tensile testing of a weld consists of applying a measured load until failure occurs in the welded specimen (tensile strength -- the maximum load per unit of original cross-sectional area obtained before rupture). The load is applied slowly by means of a tensile testing machine.

A dial, beam, or other device indicates the load on the specimen. The maximum load taken from the measuring device on the testing machine is used to figure the ultimate strength of the specimen in pounds per square inch. When it is desired to compare the strength of the weld with the base metal, the welding reinforcement is not removed. When the unit strength of the weld is required, the reinforcement is either ground, or machined flush with the base metal. When an examination of the metal at the weld is desired, the weld is machined to a size somewhat smaller than that of the base metal to insure failure in the weld. By this means, not only is the unit strength of the weld obtained, but opportunity to study a fracture through the weld metal is provided.

Where a test of ultimate strength and skill of the welder is desired, the tensile test is particularly well adapted. It is more widely used than any of the other destructive tests, particularly since the development of the portable tensile testing
machine.

The shape and dimensions of the test specimen are as shown . . . The sizes are approximate. The gauge lengths, 2 inches and 8 inches, either of which may be used, are to measure the elongation of the metal between these points. As a rule, the tensile test is applied to measure the ultimate strength of the weld. In the preparation of test specimens, frequently two plates 9 inches long by a width which depends on the number of specimens required, and a thickness as desired, are joined edge to edge by a single or double V butt weld, the welded plate being 18 inches long. The coupons or specimens are then cut out with a cutting torch sufficiently large to machine to the desired sizes. Standard sizes for tensile test specimens have been adopted by the American Society for Testing Materials.

BEND TEST

This test consists of bending a prepared specimen in the form of a U by placing it as shown . . . The object of this test is to measure the strength or ductility of the outer fibers of the weld metal. The material used is generally flat, about 6 or 8 inches long, and the width recommended is three times the thickness. The reinforcement at the weld is either ground or machined flush with the base metal. The stretch or elongation is measured by placing prick punch marks near each edge of the weld, and measuring the distance between these points. This distance is measured before and after bending. As the bending progresses, careful watch is kept for checks or cracks in the weld surface. When these occur, the load or pressure is stopped, and the distance between gauge points is measured with a flexible rule or by a bend extensometer.

The bend test is a quick means of testing and requires no special apparatus. When a testing machine is not available, a press or a vise may be used.

When the bend test is properly applied, the elongation occurring in the weld metal can be measured very satisfactorily.

Welds are tested with the bottom of the V in tension, and also with the top of the V in tension.

NICK-BREAK TEST

The nick-break test, . . ., is generally used on
double V welds. The center of the weld should be nicked by a saw slot across the thickness on both edges. The depth of the nick should not exceed 1/4 inch. The specimen should be supported at two points, ..., and should be broken by sudden blows applied at the center of the weld.

A power hammer is very satisfactory for breaking welds when the material is 5/8 inch or greater in thickness. The exact size of the stock is immaterial, although the size given is recommended. The width of the material should equal three times the thickness. A vise, press, clamp, or swage block may be used for holding the specimen.

The nick-bend test is given to test the ability of welders, the fracture showing the soundness of the weld metal, or defects, such as lack of penetration, lack of fusion, or slag inclusions. This is a simple test requiring no elaborate equipment.

IMPACT TESTS
Impact tests are largely laboratory tests because of the expense incurred in preparing the specimens. There are two impact tests in use, the Izod and the Charpy. These machines measure the resistance to impact.

The specimen is notched at the weld across one edge, the notch being of a definite size and shape. The specimen is held in a heavy clamping device, a swinging pendulum hits the specimen, fracturing it at the notch. The chief function of the impact tests is to determine the brittleness of welds. It is very important that the welding methods used on structures that may be subjected to heavy impact loads produce welds that are free from brittleness.

FATIGUE TEST
This is also a laboratory test, as it requires a special machine. In this test, the weld is subjected to a greater reversal of stresses in rapid succession. A counter indicates the number of stresses applied, while the amount of stress is dependent upon the angle through which the specimen is bent.

HARDNESS TEST
This method of testing is used in the laboratory. A section is cut through the sample at or near the weld. Hardness readings are taken on this section and indicate the strength and ductility of the weld metal.
as deposited, and also of the base metal near the weld. The hardness testing machines in general use are the Brinell, Rockwell, and Shore Scleroscope.

HOT ACID TEST

In the hot acid etching process, a 50% solution of hydrochloric acid and water is used. The solution is put in a porcelain container and heated over a gas flame to a temperature of approximately 160 degrees Fahr. The specimen, a section cut from a weld, having a fairly smooth ground surface, is immersed in the solution for a period of twenty minutes for ordinary carbon steel. After the specimen is etched, it is removed from the hot acid and washed under running water, and the "Smut" deposited on the specimen is removed with a stiff brush. It is then dried and covered with a thin coat of lacquer.

The hot acid process shows the outline of the weld and weld metal very clearly.

ETCHING TEST

An interesting method for studying the quality of welding is by means of high magnification. Cross or longitudinal sections are cut through the weld and the surface is highly polished and etched. The structure of the weld metal and any defects, i.e., poor fusion, slag inclusions, pockets, or blowholes are brought out clearly by the microscope.

For the fact non-destructive tests demand expensive, technical equipment thus placing the tests outside the realm of this study, the various tests are only listed as follows:

NON-DESTRUCTIVE TESTS

The non-destructive tests used for the inspection of welds are the:

- Hydrostatic
- Soapsuds and Submerging Tests
- Stethoscope
- X-Ray
- Gamma Ray
- Fluoroscope
Information-operation Unit XXI

Some specifications for welds demand surfaces that are entirely in the same plane or line as the base or parent-metal -- surfaces without elevation irregularities. Whenever specifications demand surfaces of even elevation, it is necessary to reduce each weld or bead to conform in line with the base-metal.

A common method used to reduce excess weld-metal to base-metal elevation is known as the "grind-file" process. This process is outlined in the following steps of procedure:

1. The first step is cooling of all welds.
2. Next, the welded article is mounted in a vise.
3. Goggles or a face shield should be put on by the operator.
4. The checking step is next in order. All working conditions should be checked carefully.
5. With all conditions as they should be, the process of grinding the welds should now proceed. Each weld should be ground almost to the surface line.
6. The work should next be smooth-finished to size with a file. Frequent checks with a straight-edge or checking tool are necessary in order to avoid excessive filing. For very smooth finishes, emery cloth used with light oil is recommended.
BUILD-UP WORK

Information-operation Unit XXII

Shop Assignment 52 by Rossi (18:78-79)
BUILDING UP BOSSES OF WELD METAL

Conditions. Position of Weld: Flat.
Materials Used: Mild-steel sheet-metal strips,
1/16 to 1/8 in. in thickness.
Size of Welding Tip: No. 2.
Oxygen Pressure: 2 lb.
Acetylene Pressure: 2 lb.
Type of Flame: Neutral.
Size and Type of Filler Rod: 1/16- to 1/8-
-diameter mild-
steel filler rod.

Flux: None

Object. To learn the control of molten metal when
a filler rod is being used.

Instructions. In building up bosses of weld metal,
a very definite effort should be made to keep the
size of the built-up metal as close as possible to
the desired dimensions. The sides and tops of the
finished bosses should have a smooth, clean appear-
ance.

Procedure. a. The apparatus should be set up, and
the oxygen and acetylene pressures should be adjusted
to the recommended values. The torch should be light-
ed and set neutral for the flame. The work plates
should be positioned flat on the welding table.

b. The operator should practice building up
bosses of weld metal about 3/4 in. in diameter and
3/4 in. in height. The finished bosses should be
inspected for smoothness and cleanliness of appear-
ance.

Questions.
1. Should the size of the built-up metal be
kept as close as possible to the desired dimensions?
2. What should be the appearance of the sides
and tops of the finished bosses?
CORNER WELDS

Information-operation XXIII

Shop Assignment 53 by Rossi (18:79)
MAKING CORNER WELDS WITH A FILLER ROD

Conditions. Position of Weld: Flat.
Material Used: Mild-steel sheet-metal strips, 1/8 in. in thickness.
Size of Welding Tip: No. 3.
Oxygen Pressure: 3 lb.
Acetylene Pressure: 3 lb.
Type of Flame: Neutral.
Size and Type of Filler Rod: 1/8-in. -diameter mild-steel filler rod.

Flux: None.

Object. To make corner welds on light-gauge metal with filler rod.

Instructions. In making corner welds with filler rods, care should be taken to get through penetration, so that the beads on the underside of the joint distinctly show end to end. The deposition technique is similar to that used for the joints previously described.

Procedure. a. The apparatus should be set up, and the oxygen and the acetylene pressures should be adjusted to the recommended values. The torch should be lighted and set for neutral flame. The plates should be tacked together at the end to form an outside-corner joint. The tacked assembly should be positioned on the welding table so that the welding of the seam can be done in a downhand position.

b. The operator should practice making corner welds. The finished welds should be inspected for appearance and penetration and should then be fractured. The fractured surface should show sound metal, proper fusion, and no slag inclusions or gas pockets.

Questions.
1. Is thorough penetration necessary in corner welds?
2. How should the bead show on the underside?
Information-operation Unit XXIV

Shop Assignment by Rossi, No. 54 (18:79-80)

MAKING BUTT WELDS

Conditions. Position of Weld: Flat.

Material Used: Mild-steel sheet-metal strips, and plates, 1/16, 1/8, and 1/4 in. in thickness.

Size of Welding Tip: Nos. 2, 3, and 5.

Oxygen Pressure: 2 lb. for No. 2 welding tip; 3 lb. for No. 3 welding tip; 5 lb. for No. 5 welding tip.

Acetylene Pressure: 2 lb. for No. 2 welding tip; 3 lb. for No. 3 welding tip; 5 lb. for No. 5 welding tip.

Type of Flame: Neutral.

Size and Type of Filler Rod: 1/16-, 1/8-, 3/16-in.-diameter mild-steel filler rods.

Flux: None.

Object. To make butt welds on sheet-metal strips as well as on heavier plates.

Instructions. In making butt welds on sheet metal, the torch tip should be held at about a 45-deg. angle, and the tip of the neutral flame should be kept about 1/8 in. away from the base metal and filler rod. When starting to weld, the filler rod should be held so that both the rod and the base metal are heated and melted at one and the same time. As the welding progresses, the base metal and the filler rod should be kept in a continuous molten state. The welding speed should be such as to permit the complete penetration of the weld and the formation of a narrow bead on the underside of the joint . . . . To ensure complete penetration, the workpieces should be spaced a sufficient distance apart, about 1/16 in., and then tacked at both ends; or if it is preferred, the end at the starting point of the weld should be closed, and the other end should be spaced a distance equal to 1/4 or 3/8 in. per ft. In this latter case, the spacing will tend to offset the contraction of the weld metal upon cooling, but a definite welding speed must be maintained, or the end where weld is finished will close up before the weld is completed.
In butt welding heavy sections, it may be necessary to bevel the adjacent edge of the plates to a single-Vee groove. Larger welding tips and filler rods should, of course, be used. The torch tip, again held at a 45-deg. angle, should be moved slowly but steadily, care being taken that both sides of the groove, from top to bottom, are being fused at the same time. The addition of the filler rod should be sufficient to build up the weld at least 1/8 in. higher than the surface of the base metal.

Procedure. a. The apparatus should be set up, and the oxygen and acetylene pressures should be adjusted to the values recommended for the size of welding tip used. The torch should be lighted and set for neutral flame. The workpieces should be butted and positioned flat on the welding table.

b. The operator should practice making butt welds on sheet-metal strips that have been spaced 1/16 in. apart and tacked together at both ends. A 1/16-in. diameter filler rod and a No. 2 welding tip should be used. The finished welds should be inspected for appearance and penetration and should then be fractured. The fractured surface should show sound weld metal, proper fusion, and no gas pockets or slag inclusions.

c. The operator should practice making butt welds on sheet metal 1/8 in. in thickness. The ends at the starting point of the weld should be spaced about 1/32 or 1/16 in. apart, and the other ends should be opened at the rate of 1/4 to 3/8 in. per ft. . . . . . A 1/8-in. diameter filler rod and a No. 5 welding tip should be used. The finished welds should be inspected, fractured, and examined, as explained under b.

d. The operator should practice making single-Vee butt welds on the beveled plates 1/4 in. in thickness. The adjacent edges should be spaced about 1/6 in. and tacked at both ends . . . . A 3/16-in. diameter filler rod and a No. 5 welding tip should be used. The finished welds should be inspected, fractured, and examined, as explained under b.

Questions.
1. In making butt welds, at what angle should the torch tip be held?
2. How far away from the base metal and filler rod should the tip of the neutral flame be maintained?
3. How should the filler rod be held?
4. What should be the spacing between the work-
pieces?
5. What should be the speed of welding?
6. Is beveling of edges necessary for the weld-
ing of heavy sections? Explain your answer?
7. What should be the motion of the torch tip
for the welding of heavy sections?
MAKING LAP WELDS

Information-operation Unit XXV

Shop Assignment 55 by Rossi (18; 81)

Conditions. Position of Weld: Flat.
Material Used: Mild-steel sheet-metal strips, 1/16-in. in thickness.
Size of Welding Tip: No. 2.
Oxygen Pressure: 2 lb.
Acetylene Pressure: 2 lb.
Type of Flame: Neutral.
Size and Type of Filler Rod: 1/16-in. -diameter mild-steel filler rod.
Flux: None.

Object. To make lap welds on sheet metal.

Instructions. In a lap joint, the top piece, being welded on an edge, will heat and melt very quickly. The bottom piece, being welded away from the edge, will not melt so quickly as the top piece. In starting the weld, the torch should be held so that the heated portion is mostly on the bottom piece, but the heat should be so directed that, when melting starts, both pieces, as well as the welding rod, will melt at the same time.

Procedure. a. The apparatus should be set up, and the oxygen and the acetylene pressures should be adjusted to the recommended values. The torch should be lighted and set for neutral flame. The plates should be lapped, tacked together, and positioned on the welding table.

b. The operator should practice making lap welds. The finished welds should be inspected for appearance and then fractured. The fractured surface should show sound weld metal, proper fusion, and no slag inclusions or gas pockets.

Questions.

1. In a lap joint, will the top piece melt before the bottom piece?
2. How should the torch be held when welding is started?
3. How should the torch be held in proceeding with bead?

Note: The operator should exercise care in starting the weld at the corners of the lapped metal. A pitted or burned condition is easily developed if proper care is not taken. The same holds true in the operation at the finish of the weld.
Making lap weld in the flat position.

Making fillet weld in tee joint in the flat position.

Making single-Vee butt weld in the vertical position.

Making corner weld in the vertical position.

Making lap weld in the vertical position.

Making fillet weld in tee joint in the vertical position.
FILLET WELDS

Information-operation Unit XXVI

Shop Assignment 56 by Rossi (18:31-32)
MAKING FILLET WELDS ON TEE JOINTS

Conditions. Position of Weld: Flat.
Material Used: Mild-steel sheet-metal strips,
1/8 and 1/4 in. in thickness.
Size of Welding Tip: Nos. 3, 4, and 6.
Oxygen Pressure: 3 lb. for No. 3 welding tip;
4 lb. for No. 4 welding tip;
6 lb. for No. 6 welding tip.
Acetylene Pressure: 3 lb. for No. 3 welding tip;
4 lb. for No. 4 welding tip;
6 lb. for No. 6 welding tip.

Type of Flame: Neutral.
Type and Size of Filler Rod: 1/8- and 3/16-in.
diameter mild-steel filler rod.

Flux: None.

Object. To make fillet welds on tee joints with filler rods.

Instructions. In welding tee joints, the heat from the welding flame should be directed mainly on the flat piece, and just enough heat should be played on the end of the vertical piece to permit both parts to melt at the same time as the filler rod.

Forehand welding only should be done, and the torch tip should be held at about a 45-deg. angle. As welding progresses, the workpieces should be kept well heated so that a definite speed may be maintained. Not too large a welding puddle should be carried, or much trouble will arise from burning holes in the vertical piece.

Procedure. a. The apparatus should be set up, and the oxygen and acetylene pressures should be adjusted to the values recommended for the size of welding tip used. The torch should be lighted and set for a neutral flame. The plates should be tacked together to form a tee joint and should then be positioned on the welding table so that the welding may be done downhand.

b. The operator should practice making fillet
welds on sheet metal 1/8 in. in thickness by using a 1/8-in. -diameter filler rod and a No. 3 welding tip. Both sides of the upright should be welded. The finished welds should be inspected for appearance and general characteristics.

c. The operator should practice making fillet welds on sheet metal 1/8 in. in thickness by using a 3/16-in. -diameter filler rod and a No. 4 welding tip. Both sides of the upright should be welded. The finished welds should be inspected for appearance and general characteristics.

d. The operator should practice making 3/8-in. fillet welds on 1/4-in. plates by using a 3/16-in. -diameter filler rod and a No. 6 welding tip. Both sides of the upright should be welded. The finished welds should be inspected for appearance and general characteristics.

Questions.

1. In making fillet welds on tee joints, on what piece should most of the heat be played?
2. Should the workpiece and the filler rod start to melt at the same time?
3. At what angle should the tip be held?
4. Should only forehand welding be done?
5. Should a large welding puddle be carried?

Explain your answer.
VERTICAL POSITION WELDS

Information-operation Unit XXVII

Shop Assignment 57 by Rossi (18:82-83)

WELDING IN THE VERTICAL POSITION

Condition. Position of Weld: Vertical.
Material Used: Mild-steel plates, 1/4 in. in thickness, some having square edges and some having one side beveled at 45 deg.

Size of Welding Tip: No. 5.
Oxygen Pressure: 5 lb.
Acetylene Pressure: 5 lb.
Type of Flame: Neutral.

Size and Type of Filler Rod: 3/16-in. -diameter mild-steel filler rod.

Flux: None.

Object. To make welds in the vertical position.

Instructions. Vertical welds may be deposited by working either upward or downward. Heavy plates should be welded by working upward, and light plates may be welded by working in either direction.

In making a vertical butt weld, the adjacent edges of the joint should be prepared the same as for flat welding. The weld should be started by preheating the workpieces around the immediate area of the weld, until the sides of the joint groove are a dull red for 1 in. or more. Then, by moving the torch tip in a U-shaped path, the sides of the groove should be brought to a full liquid state, and the filler rod should be brought into the flame, the weld being thus formed. In order to prevent excessive melting and the subsequent flowing away of the molten metal, care should be taken not to hold the flame in one position too long and not to use too large a filler rod. The torch tip should be pointed up at an angle of about 60 deg. to the plate. With this angularity of tip, the force of the flame will help to hold the metal in position. The filler rod should be directed from above at about the same angle as the torch.

The technique required for welding corner, lap,
and tee joints is similar to that used for welding butt joints.

Procedure.  a. The apparatus should be set up, and the oxygen and acetylene pressures should be adjusted to the recommended pressures for the size of tip used. The torch should be lighted and set for a neutral flame.

b. The beveled plates should be tacked together to form a single-Vee butt joint. The adjacent edges should be spaced about 1/8 in. apart. The tacked assembly should be mounted in the vertical position. The operator should practice making single-Vee butt welds by welding upward . . . . The finished welds should be inspected for appearance and penetration and should then be fractured. The fractured surfaces should show sound metal, proper fusion, and no slag or gas pockets.

c. The square-edged plates should be tacked together to form an outside-corner joint and should then be mounted in the vertical position. The operator should practice making corner welds by welding upward . . . . The finished welds should be inspected, fractured, and examined, as explained under b.

d. The square-edged plates should be tacked together to form a lap joint and should be mounted in the vertical position. The operator should practice making fillet welds by welding upward . . . . The finished welds should be inspected for appearance and then fractured. The fractured surfaces should show sound metal, proper fusion and penetration, and no slag inclusions or gas pockets.

e. The square-edged plates should be tacked together to form a tee joint and should be mounted in the vertical position. The operator should practice making fillet welds by welding upward . . . . The finished welds should be inspected, fractured, and examined, as explained under d.

Questions.

1. Should vertical welds be deposited by welding upward or downward?

2. Is the welding procedure for making corner and fillet welds similar to that used for making butt welds?

3. What should be the procedure for making vertical welds on the heavier plates?
OVERHEAD POSITION WELDS

Information-operation Unit XXVIII

Shop Assignment 58 by Rossi (18:84-85)

WELDING IN THE OVERHEAD POSITION

Material Used: Mild-steel plates, 1/4 in. in thickness, some having square edges and some having one edge beveled at 45 deg.

Size of Welding Tip: No. 5.
Oxygen Pressure: 5 lb.
Acetylene Pressure: 5 lb.
Type of Flame: Neutral.
Size and Type of Filler Rod: 3/16-in. -diameter mild-steel filler rod.

Flux: None.

Object. To make welds in the overhead position.

Instructions. In overhead welding, there is less tendency for the metal in the molten pool to drop or fall off than there is in vertical welding. In making vertical welds, the force of gravity tends to overcome the molecular attraction between base and molten metal, thus causing the molten metal to roll down the inclined surface. In making overhead welds, however, the molecular attraction and the atmospheric pressure help to overcome the pull of gravity, and thus the molten metal remains in place so long as the liquid pool does not become too large or assume the form of a large drop.

The technique used for depositing overhead welds is similar to that used for depositing flat welds. The torch and the filler rod are held at identical angles to the plates; but the plates, of course, are in an inverted position. The torch motion is the same as for flat welds. The main difference between the two deposition techniques lies in the fact that in overhead welding a slightly smaller quantity of metal should be kept in a molten state.

Procedure. a. The apparatus should be set up, and
the oxygen and acetylene pressures should be adjusted to the recommended values for the size of tip used. The torch should be lighted and set for neutral flame.

b. The beveled plates should be tacked together to form a single-Vee butt joint, with a 1/8-in. space between the adjacent edges. The tacked assembly should be mounted in the overhead position, so that the welding may be done from the underside. The operator should practice making single-Vee butt welds in the overhead position. The finished welds should be inspected for appearance and penetration and should then be fractured. The fractured surfaces should show sound metal, proper fusion, and no slag inclusions or gas pockets.

c. The square-edged plates should be tacked together to form a lap joint, and the tacked assembly should be mounted in the overhead position so that the weld may be made from the underside. The operator should practice making lap welds in the overhead position. The finished welds should be inspected for appearance and should then be fractured. The fractured surfaces should show sound metal, proper fusion and penetration, and no slag inclusions or gas pockets.

d. The square-edged plates should be tacked together to form a tee joint. The tacked assembly should be mounted in the overhead position with the plates in the horizontal and vertical planes. The operator should practice making overhead fillet welds. The finished welds should be inspected, fractured, and examined, as explained under c.

Questions.

1. Is it more troublesome to deposit vertical welds than to deposit overhead welds? Explain your answer.

2. Is the procedure required for overhead welding similar to the procedure required for downhand welding? What is the main difference?
Making single-Vee butt weld in the overhead position.

Making lap weld in the overhead position.

Making fillet weld in tee joint in the overhead position.

Making "rolling" weld on butted pipe.

Welded tee joint on tubing.

Welded tee joint (with plate) on tubing.

Welded lattice joint on tubing.

Welded lattice joint (with plate) on tubing.

Welded tee joint (with gussets) on tubing.
PIPE WELDS

Information-operation Unit XXIX

Shop Assignment 59 by Rossi (18:35-36)

WELDING OF PIPES

Conditions. Position of Weld: As instructed under Procedure.

Materials Used: Mild-steel pipes, 4 to 6 in. in diameter.

Size of Welding Tip: No. 6.

Oxygen Pressure: 6 lb.

Acetylene Pressure: 6 lb.

Type of Flame: Neutral.

Size and Type of Filler Rod: 3/16-in. - diameter mild-steel filler rod.

Flux: None.

Object. To make rolling welds and position welds on pipe joints.

Instructions. In general, especially when the pipes are fixed in place, the welding must be done by working in all positions, that is, flat, vertical, horizontal, and overhead.

If rolling welds are to be made, care should be taken to set up the pipe so that it can be turned easily during welding. In the standard neutral-flame forehand technique used for plates, the weld should be started in the upper quadrant of the pipe, at a point about 70 deg. down from the top center line of the pipe. The torch tip should be pointed upward so that the direction of the flame is nearly tangent to the circumference of the pipe. The weld should be welded by working upward until a point about 20 deg. below the top center line is reached. The pipe should then be turned until this point is about 70 deg. down from the top. The welding and the turning should be continued in this way until the joint is completely welded.

In making position welds, that is, without rolling the pipe, the weld should be started at the bottom and carried up one side of the pipe to the top, then it should be restarted at the bottom and carried up the other side, complete the weld. This, of course, involves welding in the overhead and vertical positions, as well as in the flat position. The pipe
should be positioned so that the torch can be conveniently manipulated both at the bottom and at the top of the pipe.

In butt welding, the beveled ends of the pipe should be spaced about 1/8 in. and then tacked in three places evenly spaced, with very light tacks. During welding, whenever a tack weld is encountered, it should be remelted and rewelded to ensure a sound and continuous weld.

**Procedure.**

- **a.** The apparatus should be set up, and the oxygen and acetylene pressures should be adjusted to the recommended values for the size of the welding tip used. The torch should be lighted and set for neutral flame. The beveled pipe pieces should be butted and tacked together with a 1/8-in. space between the adjacent edges.

- **b.** The tacked assembly should be set up so that it can be rolled. The operator should practice welding the seam by rolling the pipe during the welding operation . . . . The finished welds should be inspected for appearance and for complete and uniform penetration.

- **c.** The tacked assembly should be set up so that it cannot roll. The operator should practice making position welds . . . . The finished welds should be inspected, as explained under **b.**

- **d.** The tacked assembly should be set up vertically so that the seam is in a horizontal plane . . . . The operator should practice welding the seam without moving the pipe. The finished welds should be inspected, as explained under **b.**

**Questions.**

1. Does the welding of pipes involve welding in all positions?
2. What two procedures may be used in welding pipes?
3. What is the procedure for making rolling welds?
4. What is the procedure for making position welds?
Making butt weld on tubing.

Welded fish-mouth joints on tubing.

Tubing welded to flat surface.

Plate abutted to tubing and welded.

Flange joint.

Plain butt joint—notched.

Single-Vee butt joint—notched.
WELDING OF LIGHT-GAUGE TUBING

Conditions. Position of Weld: As instructed under Procedure.

Materials Used: Steel tubing, outside diameter 3/4 to 2 in., wall thickness 0.028 to 0.065 in.; steel plates, 3/16 to 1/4 in. in thickness.

Size of Welding Tip: Nos. 1, 2, and 3.

Oxygen Pressure: 1 lb. for No. 1 welding tip; 2 lb. for No. 2 welding tip; 3 lb. for No. 3 welding tip.

Acetylene Pressure: 1 lb. for No. 1 welding tip; 2 lb. for No. 2 welding tip; 3 lb. for No. 3 welding tip.

Type of Flame: Neutral.

Size and Type of Filler Rod: 1/16 to 3/32-in. diameter steel filler rod.

Flux: None.

Object. To weld light-gauge tubing with various types of joint.

Instructions. In weld-tubing structures, many types of joint may be used, but the technique that is required to weld them does not differ very much from that previously learned.

In all types of joints, the ends or edges to be welded should be smooth; if cut with the oxy-acetylene torch, they should be ground or filed.

Surfaces, as well as edges, should be thoroughly cleaned of oxides and may necessitate the removal of foreign matter. The cleaning may be done with stiff wire brush, a file, or emery paper or by grinding, if necessary.

Tack welds, when used, should range from about 3/16 to 1/4 in. in length. During the actual welding operation, all tack welds should be properly incorporated into the final weld, care being taken to obtain proper fusion.

It is important to produce a regular contour
and a proper tapering of the weld at all times. Care should be taken that the weld is properly "closed out" at the end. The finish of the weld should be properly incorporated into previously made weld.

There should be even fusion into the base metal. Penetration should be complete, but not so excessive as to protrude a great deal into the tube.

A soft neutral flame, which is neither pointed nor irregular, should be used. Either the forehand or the backhand technique may be used. The movement of the pipe, when necessary, should be regular.

Procedure. a. The apparatus should be set up, and the oxygen and acetylene pressures should be adjusted to the recommended values for the size of the tip used. The torch should be lighted and set for neutral flame.

b. Pieces of tubing with square edges should be tacked together to form an open butt joint, with a spacing of $\frac{1}{32}$ to $\frac{1}{16}$ in. between the adjacent edges. The tacked welds should be placed at three equidistance points. The welding should be done by rolling the tubing. The reinforcement of the weld should run from a minimum of $\frac{1}{16}$ in. to a maximum of $\frac{1}{8}$ in. The penetration should be full to the inside wall. The width of the finished weld should not be less than six times the tube wall thickness. The contour of the weld should be such as to be tapered gradually to the base metal on either side of the weld. The finished welds should be inspected for soundness, appearance, penetration, and fusion.

c. The process described under b should be repeated, except that the specimen should be welded in a vertical fixed position.

d. Tubing halves should be tacked together to form an open butt joint, with a spacing of $\frac{1}{32}$ to $\frac{1}{16}$ in. between the adjacent edges. The tack welds should be positioned at the ends and in the middle of the joint. The tacked assembly should be secured in the vertical position. A vertical weld should be deposited, starting at bottom of specimen. The reinforcement, penetration, contour, and width of the finished weld should be as described under b. The finished welds should be inspected for soundness, appearance, penetration, and fusion.

e. Tubes of different diameter sizes, the larger tube having a scarfed end, should be tacked together
to form a scarf joint . . . The tacked assembly should be positioned so that it can be rolled. The weld should be made by rolling the tubing. The finished welds should be inspected for soundness, appearance, penetration, and fusion.

f. Tubes of different diameter size, the larger tubes having a fish-mouth end, should be tacked together to form a fish-mouth joint . . . The tacked assembly should be positioned so that it can be rolled. The weld should be made by rolling the tubing. The finished welds should be inspected for soundness, appearance, penetration, and fusion.

g. Tubes with square and 45-deg. scarfed ends should be set at 90 and 45 deg. on top of plates and tacked in place . . . The joints should be welded in a downhand position. The fillet welds joining the tubing to plate should be made with the forehand and backhand techniques. The finished welds should be inspected for soundness, appearance, penetration, and fusion.

h. The plate should be butted radially to the tubing and tacked in position . . . The edge of the plate-abutting tube should have a square cut. The tack welds should be placed on both sides, near the ends of the plate. The tube should be set up on the welding table so that welds can be made in a flat position. The fillet-weld contour should taper off gradually at either side of the weld. The finished welds should be inspected for soundness, appearance, penetration, and fusion.

i. The plate should be tacked and inserted between two halves of the tubing. All edges should be cut square. Four tack welds should be used for one assembly, with two tacks on each side, near the end of the plate at the point of the fillet welds, and two tack welds near the ends of the plate at the point of the butt weld. The welding should be done in a horizontal position, and the specimen should be placed in a position convenient for each of the three welds. The welds should be deposited with the forehand and backhand techniques.

j. The tubes should be tacked together to form tee joints . . . The tacked assembly should be positioned flat on the welding table and should be welded in position. The welds should be deposited with the forehand and backhand techniques. The finished welds should be inspected for soundness, appearance, penetration, and fusion.
1. The tubes should be assembled and tacked together to form a lattice joint. The tacked assembly should be positioned horizontally on the welding table and should be welded in this position with the forehead and backhand techniques. The finished welds should be inspected for soundness, appearance, penetration, and fusion.

2. The tubes and plate should be assembled and tacked together to form a lattice joint with the plate. The tacked assembly should be positioned flat on the welding table and should be welded in this position with the forehead and backhand techniques. The finished welds should be inspected for soundness, appearance, penetration, and fusion.

Questions.

1. In welding tubing, does the technique differ much from the regular welding technique?
2. What are the common types of joint used in welded-tubing structures?
3. How should the surfaces or the ends of either tubes or plates be prepared and finished?
4. How long should tack welds be?
5. Should the welding be done with the forehead as well as with the backhand techniques?
6. How good should penetration be?
7. What should be the contour of the finished welds?
8. Should tack welds be properly incorporated into the finished weld? How should this be done?
Conditions. Position of Weld: Flat.
Material Used: Mild-steel plates, 1/4 in. in thickness, some having square edges and some having one end beveled at 45 deg.
Size of Welding Tip: Nos. 5 and 6.
Oxygen Pressure: 5 lb. for No. 5 welding tip;
6 lb. for No. 6 welding tip.
Acetylene Pressure: 6 lb. for No. 6 welding tip;
5 lb. for No. 5 welding tip.
Type of Flame: Slightly oxidizing.

Flux: Brazing flux.

Object. To bronze-weld mild-steel plates.

Instructions. Brazing is a process in which the filler metal used is a nonferrous metal or alloy whose melting point is higher than 1000 deg. F., but lower than that of the metals or alloys being joined.
Numerous kinds of filler rods are available for bronze welding. Some of these will flow much easier than others. In working with bronze rods which do not flow easily, the torch should be manipulated with a rotary motion, from side to side, much in the same manner as in fusion welding mild steel.
Before being melted, bronze filler rod should be coated with flux, either while it is cold or after it has been heated, depending on the particular flux being used. This operation is known as "fluxing the rod." If a liquid flux is being used, it is advisable to brush thin coats of it on edges to be welded.
For bronze welding, the flame should be adjusted to be slightly oxidizing. This will ensure much better bonding between the bronze filler and the base metal. The proper flame may be obtained by first
setting the torch for a neutral flame and then closing the torch acetylene valve slowly until the inner cone has been reduced in length by about one-tenth its original length.

One of the most important steps in bronze welding is the "tinning" operation, in which there is formed a molecular union, or bond, between the bronze filler metal and the base metal. The strength of the welded joint is determined by the strength of this bond. The tinning should be carefully carried out. By moving the flame in a circular path for some distance around the starting point of the weld, the base metal should be brought gradually up to a red heat. As soon as the base metal begins to glow, the fluxed filler rod should be melted and deposited on the heated spot. If the metal has been heated to the proper temperature for bronze welding, the molten-bronze filler metal will flow in a thin layer and will spread out over the heated area. If the process has been correctly carried out, this flow will have the appearance of water spreading over a clean damp surface, rather than that of water spreading over a greasy surface. If the metal has been overheated, the bronze filler will tend to boil and to form into drops which roll off as fast as the rod is melted. If the base metal has not been heated sufficiently, the bronze filler will not flow properly and thus will not produce the tinning coating.

When the tinning action starts, more bronze filler should be added to build the weld up to the desired size. At first, the puddle should be small, but it should be increased in size as it is moved forward until it completely fills in the joint groove. As welding progresses, it is essential that the tinning action take place constantly just ahead of the puddle.

The inner cone of the slightly oxidizing flame used should be held 1/8 to 1/4 in. away from the surface of the metal. The angularity of the torch tip varies, depending on the position of welding; but, in general, the flame should be pointed ahead of the completed part of the weld at an angle of about 45 deg. The puddle should be under and slightly behind the flame. Both the rod and the flame should be given a slight sideways or circular motion in the puddle, very much the same as in the forehand-welding technique, except that the motion of the two are opposite to each other.
In bronze welding lap joints, the bottom and the top of the lap should be heated to a very dark red, and the filler rod should be applied entirely across the width of the lap, care being taken that the bottom sheet is kept as hot as the top sheet. If a uniform heat is maintained, the bronze will flow inside the lap and cover the entire surface. When this has been done, a fillet weld should be built across the top edge of the lap. The assembly should then be turned over, and another fillet weld should be made along the edge of the bottom lap.

After depositing the weld, it is important that the weld be allowed to cool slowly to ambient temperature. Also, the finished weld should be wire-brushed to remove any excess flux or slag left behind by the welding operation.

Procedure. a. The apparatus should be set up, and the oxygen and acetylene pressures should be adjusted to the values recommended for the size of the welding tip used. The torch should be lighted and set for a slightly oxidizing flame.

b. Beveled plates should be tacked together to form a single-Vee joint, with 1/16-in. space between them. The tacked assembly should be positioned flat on the welding table. The operator should practice making bronze welds by using a 1/8-in. ordinary bronze filler rod, and a No. 5 welding tip. The finished welds should be inspected for appearance and penetration and should then be fractured. The fractured surfaces should show sound metal and no slag inclusions or gas pockets.

c. The process described under b should be repeated, but a manganese-bronze electrode should be used in this case.

d. The process described under b should be repeated, but a fumeless-bronze electrode should be used in this case.

e. Square-edged plates should be lapped lengthwise about 3/4 in., and tacked together. They should then be positioned flat on the welding table. The operator should practice welding the laps by using a 3/16-in. ordinary bronze electrode and a No. 6 welding tip. The finished welds should be inspected for appearance and should then be fractured. The fractured surfaces should show sound weld metal and no slag inclusions or gas pockets.
f. The process described under e should be repeated, but a manganese-bronze electrode should be used in this case.

g. The process described under e should be repeated, but a fumeless bronze electrode should be used in this case.

Questions.
1. What is brazing?
2. Are there some bronze filler rods that will flow more than others?
3. Should a bronze filler rod be fluxed before it is deposited? How should this operation be carried out?
4. What type of flame should be used for bronze welding? Explain your answer.
5. What is "tinning"? How should it be done?
6. At what angle should the torch tip be held?
7. How should a lap joint be bronzed?

Shop Assignment 63 (in part) by Rossi (18:92)
BRAZING OR BRONZE WELDING CAST IRON

Instructions. The technique required for bronze welding cast iron does not differ much from that required for bronze welding mild steel, although the rate of deposition is somewhat less.

The parts to be united should be properly prepared and properly spaced. The adjacent edges of the joint should be beveled to a 45-deg. angle and spaced about 1/16 in. apart. The filler rod should be properly fluxed.

The cast-iron parts should be heated to a very dull red and bronze-welded together by filling the groove up until the weld is a trifle higher than the top surface of the work.

Lesson No. 11 (in part) by Plumley (17:163)
Bronze Welding Cast Iron

The condition of the surface of the cast iron is, however, a matter of much importance in bronze welding. The surface must be clean, free from rust, grease, dirt and scale. A rough surface is better than a smooth one, and one which has been ground or
Machined presents greater difficulty than other methods of preparation. Machined or ground surfaces are extremely difficult to tin with the bronze and the adhesion to them is poor. This is apparently due to the graphite flakes which are exposed by the machining operation or the grinding wheel. The difficulty, however, can be overcome by sand blasting, or by annealing the surface to a bright red. After this has been done, coating the surface with bronze and making it adhere in a satisfactory manner is a very simple process.

Rate of Cooling Is Very Important

The condition of the weld, therefore, is one which can be controlled by care on the part of the welder. The casting must be prepared by preheating slowly to equalize the strain of expansion, and must likewise be cooled slowly to prevent the formation of white iron and hard unmachinable welds. Such requirements necessitate several hours of preheating (depending on the job) and sometimes twelve or fourteen hours for cooling with the result that fusion welding of cast iron and bronze welding are slow processes at best when work is carried on properly.

Slow cooling of cast-iron bronze welds may be successfully accomplished by burying the brazed casting in lime or any similar non-inflammable powdered material. The casting should remain buried or covered until it is cool; this may take several hours. After the metal is cool, all of the powdered material should be removed from it.
Sketch Showing the Torch and the Red Held as in Fusion Welding. Bronze Welding Should Not Be Done in this Manner. The Luminous Cone of Flame in this Position would Burn Both the Rod and that Portion of the Bronze Weld Which has been Completed.

Sketch Showing the Method of Heating the Cast Iron to a Cherry Red Heat Immediately in Advance of the Bronze Weld. In this instance the Luminous Cone of Flame is Held Close to the Casting to Utilize all of the Heat, but is Immediately Withdrawn When in Contact with Either the Bronze Weld Already Made, or the Bronze Rod.

When the Area of the Casting Immediately Forward of the Weld has been Heated to a Cherry Red, the Torch is Partly Withdrawn and the Envelope of the Flame Utilized to Melt the Bronze Rod over the Surface to Thoroughly Coat or Tin It. This Section of the Weld is Then Built Up to its Full Thickness After the Tinning Operation, the Motion of the Rod May be the Same as in Fusion Welding if Desired.

Welding First at One End and then at the Other should be Continued Until the Weld is Completed.
HARDENING AND TEMPERING by Schwarzkopf (19:134-138)

59. Hardening. Tool steel is hardened by heating it to a full red heat and then quickly plunging it into a bath of clean, cold water. Other liquids or additions affect the hardness. Salt or saltpeter intensify the effect, in that they produce greater hardness. Oil or lime or soda, on the contrary, lessen the intensity of the effect. Steel heated to a full red and cooled by plunging it into mercury becomes glass hard, and, therefore, too hard to be worked under a file. It will break easily when an attempt is made to bend it.

60. Tempering. By heating steel, which has been hardened, to certain temperatures, it is possible to release various percentages of the combined carbon and in this way to reduce the hardness as desired. This operation is called tempering. In order to accomplish this, every tool is first given a certain high grade of hardness. It is then tempered down to that grade of hardness which is most suitable for the uses for which it is intended.

In order to make entirely clear the process of tempering, we shall consider some one tool and explain the procedure step by step. Let us consider a chisel, which is very much used by every worker. The chisel is forged and then ground. To temper it, heat the forged or sharpened end slowly and carefully in the hardening furnace or in a charcoal or coke fire to a full red heat. Cool it immediately in water, plunging the cutting end about one inch under the surface and moving it slowly back and forth, and slightly up and down. The backward and forward motion cools the end more quickly by continually bringing the steel in contact with new cold water, thus preventing the formation of a heat insulating layer of steam surrounding the tool. The up and down motion prevents the fracturing of the steel at any definite water line, a result frequently observed in the tempering of tools. This fracture is due to the contraction of one portion away from the other at the water line.
As soon as the hardening process is completed, the tempering process should be begun. In this operation use is made of a piece of emery cloth fastened to a stick or of a small emery block, to rub the surface of the end of the chisel; or the tool may be rubbed on the cement floor or any hard abrasive to polish its surface. The tempering is accomplished by heat which still remains in the uncoiled portion of the tool being conducted to the cooled or cutting end. In this way, by gradual conduction of heat, the cutting end of the tool is raised through a succession of temperatures and the polished surface becomes oxidized. The oxidized surface takes on various colors, depending upon the temperature. The first color observed is light or pale straw, followed in order by dark straw, brownish-red, and purple, then dark blue and light blue. These colors definitely indicate important changes in character and hardness which take place in the steel at the different temperatures, and they serve, therefore, as a valuable criterion for judgment in tempering steels to desired hardesses.

If the tempering has been unsuccessful or unsatisfactory, the tool may be retempered. Before doing so, however, it should be annealed or softened by heating to a red heat and allowing it to cool slowly, after which the original procedure for tempering is followed. In tempering, steel loses a very small portion of its carbon, and by repeated tempering the tool is spoiled.

Table of Tempering Colors

1. Light or pale straw, 425-450 F. Lathe and planer tools to be used with hard metals, such as steel and cast iron.
2. Dark straw, 465 F. Lathe and planer tools for wrought iron and the softer metals, reamers, milling cutters, etc.
3. Red brown, 510 F. Center punches, machine punches, dies and stone drills.
4. Purple, 530 F. Taps, drills and tools used for bone and leather. Punches, chisels, etc.
5. Dark blue, 565 F. Cold and cape chisels, hand punches, hatchets, table and hunting knives.
6. Light or pale blue, 605 F. Screwdrivers, etc.
OPTIONAL UNITS

Informational-operational Unit XXXIII

On the next three pages are suggestions for additional units of study. They are optional and provide, if time permits, for further experience in student development in oxy-acetylene welding.

The suggestions are:

1. Making a parts box
2. Reparing a broken fender
3. Making a milking stool
4. Making an ice pick
5. Making a welding table
6. Making an automobile support
Parts Box
A Break in the Rear Fender of an Old Car Before Welding. The Binding Wire is Skew to the Left, Where It has Broken Away from the Metal.

This Sketch Shows the same Break, as Illustrated in Figure 13, Half Welded. The Weld Will be Completed from A to B, and Pounded to a Smooth, Even Contour with Two Hammers.

The Method of Hammering the Fender is Indicated in this Sketch. A Heavy Hammer is Used Underneath the Fender and a Lighter Hammer on Top. In This Manner the Edges Can be Kept Smooth and Even and the Original Contour of the Fender Maintained.

This Figure Shows a Method Often Used by Welders Who begin at the Bond Edge of the Fender and Work in Toward the Beginning of the Break, This Method is not Recommended. This Sketch also Shows the Use of Wet Asbestos which will be Found Very Handy to Protect the Painted Surface and to Prevent as Much Distortion of the Metal as Possible.
A Milking Stool Made of Sheet Steel with All Joints Welded.

Sketch of a Simple Welding Table for a School Installation.

An Ice Chisel Made of a Piece of One Inch Pipe Welded to a Part of a Spring Leaf from an Automobile.

Supports for Automobiles Made of Scrap Pieces of Pipe Welded Together. The Supporting Pipe Is Bent Slightly as Indicated to Prevent the Axle of the Car from Slipping Off the Support.
ESSENTIAL FACTORS IN THE SHOP DEMONSTRATION

1. Have the demonstration outline carefully prepared.
2. Exercise caution in demonstrating to large groups.
3. Employ varied demonstrating techniques.
4. Have tools and equipment in good condition.
5. Have a specific table or bench for demonstrations.
6. Provide accommodations for students.
7. Make arrangements for all necessary visual aids.
8. Have everything in readiness before demonstration.
9. Have samples of types of work.
10. If need be, distribute operation sheets.
11. Adhere to definitely scheduled demonstrations.
12. State the aim and purpose of each demonstration.
13. Correlate the old material with the new material.
14. Excessive talking while demonstrating is not favored.
15. Avoid "slips" in the procedure of the demonstration.
16. Encourage questions about the demonstration.
17. Avoid lengthy discussions.
18. Provide for a student demonstration follow-up check.
19. Practice in private to overcome "rustiness."
20. Demonstrate with materials other than the student's.
21. Arrange for student operation after the demonstration.
22. Occasionally, follow-up tests of the objectives are means of judging the effectiveness of the process.

23. When it is deemed advisable, the demonstration may be repeated with minor modifications.

24. Compensate any faulty skills in the demonstration by improving the verbal and instructional techniques.

25. Circulate the product of the demonstration through the class for inspection purposes.

26. Avoid the concentration of all of the demonstrations at the beginning of the course.

27. Beware of demonstrating too many manipulations during one short period of time.

28. In certain carefully guarded cases, the demonstration of incorrect methods may have value.

29. Sometimes it is good policy to demonstrate operations the student is not expected to use.

30. Do not neglect the spontaneous demonstration; from boy to boy; from bench to bench.

31. Some processes may require the student to do the work step by step with the demonstrator.

32. Quite often the student will learn more readily if he assumes the position of the demonstrator.

33. Do not, through demonstrations, make a student's project for him.

34. If there are many methods, demonstrate the one most acceptable and adaptable to the group.

35. In recognition of individual differences, explain other accepted methods of operation.

36. While on field trips to shops, try to arrange for an expert to demonstrate some process.

37. Call in tradesmen for special demonstrations.
38. Avoid the minimization of demonstrations; too often shop teachers neglect demonstrations.

39. Recognize the fact that formal group demonstrations can not take the place of individualized instruction.

40. Some students are capable of giving demonstrations, but do not forsake standards for such demonstrations.

41. Displace hesitancy by demonstrating during visits from the supervisor if the schedule demands.

42. Establish yourself as a real teacher by demonstrating to the class during "open house" or visitor's day.

43. Always appreciate your position and relations to the students, the school, and the community.
Corvallis, Oregon
April 18, 1942

State Superintendent of Public Instruction
(Address)

Dear Sir:

Realizing the need for a uniform course of study for oxy-acetylene welding for high schools throughout the nation, I have selected as my graduate thesis study in Industrial Arts Education "A Course of Study for Elementary Oxy-acetylene Welding."

Your assistance in answering the questions of the inclosed questionnaire, and the forwarding to me, if your state has one formulated, a copy of your state course of study dealing with welding, will be greatly appreciated. I shall most appreciatively entertain any constructive criticisms or suggestions you may care to offer in the questionnaire under the heading "remarks."

I shall be very grateful to you if this favor may receive your attention at your earliest possible convenience.

Thanking you for your consideration of the study, I am,

Yours truly,

C. H. Oylear
955 Van Buren St.
QUESTIONNAIRE.

1. Yes No. Does your state course of study include welding?

2. Yes No. If your answer to No. 1 is no, are any steps being taken to formulate a course of study for welding?

3. Yes No. In the event nos. 1 and 2 are both no, do you deem a course of study for welding advisable in your state course of study?

4. Please check the following as to welding objectives:
   (a) Yes No. To develop tradesmen only.
   (b) Yes No. To develop an understanding and appreciation of welding with some degree of skill.
   (c) Yes No. An offering for a student exploratory course.
   (d) Yes No. A leisure time course.
   (e) Yes No. An orientation course for failing students.
   (f) Yes No. Primarily for school plant maintenance.
   (g) Yes No. As a guidance and counseling technique in discovering student interests, aptitudes, and abilities.
   (h) Yes No. As a means of individualized instruction.
   (i) Yes No. To satisfy certain industrial demands during times of emergency.
   (j) Yes No. A means of correlating the high schools and industry.

5. Yes No. Should the course be an allied development, as for an example with forging?

6. Yes No. Should arc welding be as of a separate course of study in itself?

7. __________ Recommended amount of time for the course: 9 weeks, 1 semester, 2 semesters, suggested.

8. Remarks:

9. Prerequisite, if any: