AN ABSTRACT OF THE THESIS OF

LEONARD CARL LOVE for the M.S. Degree in Ind. Arts Educ.

Date thesis is presented August 7, 1963

Title A STUDY OF A METALLURGICAL BACKGROUND OF WELDING INSTRUCTORS AT THE COLLEGE OR UNIVERSITY LEVEL

Abstract approved [redacted]

This study was set up to examine selected aspects of the knowledge of welding metallurgy that is a part of the background of present teacher educators who teach welding courses for Industrial Arts majors.

Specifically this study was made to answer the following questions:

1. What knowledge is now possessed by college welding instructors as it applies to the field of welding metallurgy?

2. What knowledge is needed by college welding instructors as revealed by their own opinions?

3. What basis can be established for the selection of principles of welding metallurgy to be included in welding courses for Industrial Arts teachers at the college level.

A review of significant literature revealed that this survey is unprecedented in the field of education.

The college teachers responding to this survey favor improving the technical and theoretical level of the college and university welding courses conducted for Industrial Arts teacher education majors. Only a few of the teacher education institutions have specific courses in metallurgy yet many indicate metallurgical theory desirable. Teachers participating in this study favor the welding course that has approximately two-thirds laboratory and one-third lecture. Participants have shown a preference for some textbooks and reference books with as many as eighteen teachers out of the 58 participating in the survey using the same textbook.

The recommendations for further research include the following: (1) Additional study of the laboratory exercises and requirements to see if these are in harmony with course objectives; (2) a survey of the course outlines--including the study schedule--to evaluate the technical level of required study; (3) and a survey of the other states to compare aspects of metallurgical knowledge that teacher educators of welding courses possess at the present time in relation to what recognized educators feel teachers should possess.

# A STUDY
# OF A METALLURGICAL BACKGROUND
# OF WELDING INSTRUCTORS AT THE COLLEGE OR UNIVERSITY LEVEL

by

LEONARD CARL LOVE

A THESIS

submitted to

OREGON STATE UNIVERSITY

in partial fulfillment of
the requirements for the

degree of

MASTER OF SCIENCE

August 1963

APPROVED: [redacted]

Major Professor and Head of Department of Industrial Arts

[redacted]

Dean of Graduate School

Date thesis is presented August 7, 1963

Typed by Norma Hansen

ACKNOWLEDGEMENT

The author sincerely acknowledges the assistance and encouragement offered by Dr. Chester B. Ainsworth, Professor and Head of the Department of Industrial Arts; Dr. Charles B. Friday, Professor of Economics, Chairman of Department; and Asa A. Robley, Associate Professor of Production Technology, all of Oregon State University.

Further acknowledgement for the constant advisement in previous years given by George B. Cox, Professor emeritus of Industrial Engineering and Industrial Arts.

A thanks to the college and university professors who willingly devoted their time to answer the correspondence involved in gathering data.

And finally a special thanks to my dear wife Barbara and our children who sacrificed many hours of companionship to permit this manuscript.

TABLE OF CONTENTS

## LIST OF TABLES

LIST OF TABLES Continued

LIST OF TABLES Continued

# A STUDY OF A METALLURGICAL BACKGROUND FOR WELDING INSTRUCTION AT THE COLLEGE OR UNIVERSITY LEVEL

Industry has developed to a point where the application of metallurgy to manufacturing processes involving welding has attained great importance. This suggests that a knowledge of metallurgy is important to those individuals teaching welding courses to Industrial Arts teacher education majors at the college or university level.

This study involves selected aspects of metallurgy that pertain to and contribute to the background of personnel involved in teaching welding courses in Industrial Arts teacher education programs. It is assumed that a college or university instructor of Industrial Arts will have some background in welding metallurgy.

The desirability of such knowledge is shown in the following quotation from the Welding Handbook (1, p. 4.2):

> A knowledge of welding metallurgy is useful from the very start of welding where the first problems of oxidation and nitrogen fixation arise, to the final operation where the microstructure and resulting mechanical properties may depend upon the rate of cooling from a high temperature. Where certain requirements for mechanical properties or for corrosion resistance must be met by the weldment, a knowledge of metallurgy will help in planning the welding procedure and any necessary postweld treatment.

This study was made to determine how extensive a metallurgical background educators possess as well as the background recommended by welding instructors in the field of Industrial Arts Education at the college or university level.

Encouragement for this study has been received from many Industrial Arts welding instructors who have been contacted by the writer in the last ten years. These instructors have expressed concern over the amount of instruction in welding metallurgy available in college and university curriculums.

## Statement of the Problem

This study was made to examine various aspects of the knowledge of metallurgy that present college level Industrial Arts instructors of welding believe they possess and some aspects which they think would help them become better teachers of welding courses.

Specifically this study was made to answer the following questions in relation to certain principles of welding metallurgy:

1. What knowledge is now possessed by college welding

instructors of Industrial Arts?

2. What knowledge is needed by college welding instructors of Industrial Arts as revealed by their own opinions?

3. What basis can be established for the selection of certain welding metallurgy principles to be included in welding courses for Industrial Arts teachers?

## Scope of the Study

Information for this study was collected through the use of a survey form involving Industrial Arts teachers at the college or university level. The survey form was mailed to a group of teachers west of the Mississippi River who were teaching courses which served Industrial Arts education majors.

## Significance of the Study

It is hoped that this study will be an aid in the improvement of the teacher education curriculum for Industrial Arts majors in the welding area. Further it is hoped that this study will encourage Industrial Arts

teachers on the college level to be cognizant of the need for a sound background of welding metallurgy. Further it is hoped that this study may serve as an aid in establishing the technical content of welding courses in the teacher education programs. It is further hoped that this study will help establish a criterion for judging the metallurgical background of those who are concerned with instructing welding courses for teacher educators.

## Collection of Data

The Industrial Teacher Education Directory was used to obtain names of persons who were teaching welding courses on the college level. From this list, preliminary letters were sent out asking these instructors if they would be willing to participate in a survey. In this first letter an effort was made to convince the respondents of the importance of the study. As a device to create interest among the respondents, provision was made for them to indicate their desire to receive a copy of the results. (For a copy of this letter see the Appendix, p. 74). It should be noted that all of the persons who replied to the first letter requested a summary of the results.

One hundred and twenty-five letters with self-addressed post cards enclosed were sent for the first contact. Of the 90 post cards returned, 87 volunteered to answer questions for the study. In response to the post cards which listed the teachers' current addresses, 87 survey forms were prepared and mailed. Fifty-eight of them were received for a return of 66 percent. The results are tabulated and summarized in this study. Forty-eight colleges and universities representing 20 states west of the Mississippi River cooperated in this study.

# CHAPTER II

## REVIEW OF RELATED LITERATURE

A survey of literature was made to determine whether a study of this type had recently been conducted. Nothing directly concerning this study was found; however, the search did reveal other studies which may have a bearing on the background of Industrial Arts teacher educators.

In a thesis prepared by Van Arsdale ( 4 , p. 89), he indicates that welding is often not presented by Industrial Arts teachers because many are not familiar with the applications nor skilled in performing the processes. Van Arsdale ( 4 , p. 91) recommends that the teacher education institutions should develop a more complete program of instruction in welding with ample time for instructors to acquire skills and to study the equipment and its uses in industry.

Other information which may have a bearing on the background of Industrial Arts teacher educators is found in a thesis prepared by D. R. Enderby ( 2 , p. 87) entitled, "A Study of Industrial Arts Programs of the Teacher Training Institutions of Oklahoma to Determine If

the Teachers of Industrial Arts in High Schools of Oklahoma Are Receiving Adequate Training." His findings indicate that inadequate preparation had been received in metalworking and hand tool processes.

Some of the outstanding leaders of America in the field of metallurgy have written about the relationship of metallurgy to other subjects and with Guy suggest the value of a knowledge of metallurgy to those who would teach courses involving welding when he says:

> All human knowledge is related, and metallurgy is an outstanding example of a subject connected by generous transition zones to many other areas of knowledge. These relationships are of two kinds: the art and science of metallurgy depend on the techniques and principles of other subjects and, on the other hand, metallurgy is responsible for supplying construction materials for use in other fields. Guy (3, p. 2)

Because a search for related material did not produce any directly related information, the writer believes that this study may become a significant contribution toward improving the background of the teacher educator in the field of welding.

# CHAPTER III

# FUNDAMENTALS OF THE STUDY

Data were gathered for this study from a questionnaire-opinionnaire survey which consisted of four major parts. Each principle, statement, or question of these major parts will be discussed in detail. Accompanying the detailed discussion will be a tabulation showing the response from those individuals selected for the survey who were teaching welding courses to Industrial Arts teacher education majors at the college or university level.

Technical principles and concepts involving aspects of welding metallurgy found in the questionnaire-opinionnaire were selected by the writer from a group of reference books written by authors who are recognized authorities in the science of welding metallurgy. A list of these books and authors appears in the Appendix, p. 66.

## Construction of the Survey

In the survey eleven terms describing aspects of metallurgy were chosen by the author for Part I. These terms were selected to establish insofar as this study was

concerned, concrete examples with which to judge the emphasis respondents would place on these terms which are related to the metallurgical background needed by the individual teaching welding courses to Industrial Arts teacher education majors at the college or university level.

A series of statements was constructed for Part II so the select group of teachers mentioned above could indicate the importance of these statements as they pertain to this study. One of these statements contained seven terms. Participants were asked to select one of four responses which would indicate whether or not teacher education majors of three different levels of educational achievement should have enough knowledge to explain these terms to others.

Part III contained a group of questions in which the respondents were asked to indicate how much time, in their opinion, should be devoted to various aspects of their welding class schedule in relation to either theory or skill and manipulative practice.

Part IV asked for a listing of textbooks which were used for beginning welding courses, advanced welding

courses, and a metallurgy course (if available to Industrial Arts teacher education majors). Part IV also asked for a course outline in which the previously mentioned textbooks were used either as a reference or a required textbook.

## Results of the Survey

The results of the survey are presented on the following pages. A discussion concerning each table will be included.

Part I. Terms in Part I were constructed so that respondents could indicate the extent to which they felt it necessary to emphasize these areas as a part of their background as college welding instructors of courses for Industrial Arts teacher education majors.

The first term in Part I was "Metals as They Exist in the Atomic State." (See Glossary in Appendix, p. 67 for this and other technical terms.) Eighty-one percent of those answering indicated a "light introduction" or "moderate emphasis" should be given this term in welding courses for Industrial Arts teacher education programs. A few suggested "heavy emphasis" or a rating that indicated

it was "too complex and should not be used" in the teacher education welding course. Table I below provides the complete information.

TABLE I

Metals as They Exist in the Atomic State

| | Number | Percent |
|---|---|---|
| Heavy emphasis | 4 | 7 |
| Moderate emphasis | 17 | 29 |
| Light introduction | 30 | 52 |
| Too complex and should not be used | 7 | 12 |
| Total | 58 | 100 |

Table II, p. 12, involves the term which reads "Solidification of Metals and Alloys." The table shows that a large group of respondents were not able to decide whether this term should be important or not as a part of the information that makes up the background of the teacher educator. "Moderate emphasis" was chosen by 45 percent of the respondents in answer to the principle, "Solidification of Metals and Alloys." Two respondents indicated this principle, "Too complex and should not be

used" as information that contributes to the background of teacher educators in welding courses.

TABLE II

Solidification of Metals and Alloys

| | Number | Percent |
|---|---|---|
| Heavy emphasis | 12 | 21 |
| Moderate emphasis | 26 | 45 |
| Light introduction | 18 | 31 |
| Too complex and should not be used | 2 | 3 |
| Total | 58 | 100 |

The next term reads "State and Behavior of Crystal Structure." One-half of the Industrial Arts teachers indicated this "State and Behavior of Crystal Structure" should receive heavy to moderate emphasis as indicated on Table III, p. 13. Forty-five percent indicated it should receive a "light introduction" with only five percent indicating they were not in favor of using the term as a part of the study of metallurgy for teachers of welding classes for Industrial Arts teachers.

TABLE III

State and Behavior of Crystal Structure

| | Number | Percent |
|---|---|---|
| Heavy emphasis | 10 | 17 |
| Moderate emphasis | 19 | 33 |
| Light introduction | 26 | 45 |
| Too complex and should not be used | 3 | 5 |
| Total | 58 | 100 |

Table IV, p. 14, shows the degree of importance attached to "Structure and Properties of Alloys" as indicated by the respondents as it pertains to the background of the individuals teaching welding courses to Industrial Arts teacher education majors at the college or university level. Respondents indicated that the study of "Structure and Properties of Alloys" should occupy a part of the welding course given to teacher educators. The amount of emphasis that was placed on this term by the respondents is shown in Table IV, which indicates that 42 percent of the respondents chose "heavy emphasis" and 39 percent of the respondents chose "moderate emphasis." The importance

of this term as it contributes to the background of the welding instructor in Industrial Arts Education is further indicated within the framework of this study by the fact that only one respondent indicated "too complex and should not be used."

TABLE IV

Structure and Property of Alloys

| | Number | Percent |
|---|---|---|
| Heavy emphasis | 23 | 42 |
| Moderate emphasis | 22 | 39 |
| Light introduction | 10 | 18 |
| Too complex and should not be used | 1 | 1 |
| Total | 56 | 100 |

The degrees of emphasis on "Production of Metals" indicated by the respondents are reported as shown in Table V, p. 15, as follows: 47 percent "heavy emphasis," 38 percent "moderate emphasis," and 14 percent a "light introduction." The degree of emphasis attached to the term indicates that nearly half of the respondents consider this very important. Conversely, many would give it

only a "moderate emphasis" or a "light introduction" as a part of the metallurgical background of welding teachers in the field of Industrial Arts Education.

TABLE V

Production of Metals

| | Number | Percent |
|---|---|---|
| Heavy emphasis | 27 | 47 |
| Moderate emphasis | 22 | 38 |
| Light introduction | 8 | 14 |
| Too complex and should not be used | 1 | 1 |
| Total | 58 | 100 |

The next principle reads, "The Theory of Metalworking," details of which are in Table VI, p. 16. This table indicates that a majority, or 64 percent, of the respondents would place "heavy emphasis" on this principle for use in welding classes as it pertains to the background of individuals teaching welding courses to Industrial Arts teacher education majors at the college or university level.

TABLE VI

The Theory of Metalworking

| | Number | Percent |
|---|---|---|
| Heavy emphasis | 35 | 64 |
| Moderate emphasis | 17 | 31 |
| Light introduction | 3 | 5 |
| Too complex and should not be used | 0 | 0 |
| Total | 55 | 100 |

The degree of importance attached to "Principles of Heat Treatment" is indicated in Table VII, p. 17. This table indicates this is another term in which heavy to moderate emphasis was indicated by the majority of the replies. This table shows, as a result of the respondents' opinion, "Principles of Heat Treatment" would be included as an important part of the background of college welding teacher educators involved in this study. The importance of this term is shown in Table VII which indicates that 64 percent of the respondents indicated "heavy emphasis." A further indication that this term was important is that none of the respondents indicated that "Principles of Heat Treatment" were too complex to be a part of the welding

teacher educators' background.

TABLE VII

Principles of Heat Treatment

| | Number | Percent |
|---|---|---|
| Heavy emphasis | 37 | 64 |
| Moderate emphasis | 16 | 28 |
| Light introduction | 5 | 6 |
| Too complex and should not be used | 0 | 0 |
| Total | 58 | 100 |

The term "Theory of Metal Joining" was considered important to the background of college teacher educators by 70 percent of the respondents who chose "heavy emphasis" as indicated in Table VIII, p. 18. Twenty-five percent indicated "moderate emphasis" as their selection, while four percent believed that a "light introduction" was sufficient. As a matter of interest, the teacher who indicated that this term should not be used, felt that none of the terms listed in Part I should have any more emphasis than a "light introduction" as information which contributes to the background of teacher educators.

TABLE VIII

Theory of Metal Joining

| | Number | Percent |
|---|---|---|
| Heavy emphasis | 40 | 70 |
| Moderate emphasis | 14 | 25 |
| Light introduction | 2 | 4 |
| Too complex and should not be used | 1 | 1 |
| Total | 57 | 100 |

"Heat Treating Techniques" is a term that was indicated as important by the teacher educators in relation to this study. As indicated in Table IX, p. 19, the largest group, or 48 percent of the respondents, selected "moderate emphasis," and the next largest group, or 46 percent, indicated the response "heavy emphasis" should be placed on this term which makes up a part of the metallurgical background of the teacher educator. This is in contrast to only one percent of the 58 respondents who had the opinion that "Heat Treating Techniques" was "too complex and should not be used" as a part of the background for individuals teaching welding courses to Industrial Arts teacher education majors. It seems apparent, therefore,

that this "Heat Treating Techniques" was considered quite important and as such should be a part of the knowledge possessed by Industrial Arts teacher educators.

TABLE IX

Heat Treating Techniques

| | Number | Percent |
|---|---|---|
| Heavy emphasis | 26 | 46 |
| Moderate emphasis | 28 | 48 |
| Light introduction | 3 | 5 |
| Too complex and should not be used | 1 | 1 |
| Total | 58 | 100 |

Opinions of the respondents as shown in Table X, p. 20, concerning "Methods and Principles of Cutting," indicate the teachers participating in the survey feel this is quite an important part of their background of knowledge. Fifty percent of the respondents indicated "heavy emphasis" should be placed on this principle, and 40 percent of the respondents indicated "moderate emphasis." None of the respondents felt the principle was "too complex and should not be used" as information that

contributes to the background of those teachers within the framework of this study.

TABLE X

Methods and Principles of Cutting

| | Number | Percent |
|---|---|---|
| Heavy emphasis | 29 | 50 |
| Moderate emphasis | 23 | 40 |
| Light introduction | 6 | 10 |
| Too complex and should not be used | 0 | 0 |
| Total | 58 | 100 |

Table XI, p. 21, which involves the term "Destructive and Non-destructive Testing," shows that 50 percent of the respondents have indicated that "moderate emphasis" should be placed on this principle as it pertains to the background of college teacher educators of welding courses. Almost an equal number of respondents indicated the responses "heavy emphasis" and "light introduction." Only four percent said it was "too complex and should not be used" for the background of welding teacher educators.

TABLE XI

Destructive and Non-destructive Testing

| | Number | Percent |
|---|---|---|
| Heavy emphasis | 14 | 24 |
| Moderate emphasis | 29 | 50 |
| Light introduction | 13 | 22 |
| Too complex and should not be used | 2 | 4 |
| Total | 58 | 100 |

Part II. Statements in Part II were constructed so the respondents could indicate whether or not they agree the various areas as listed should be a part of the background of the person teaching welding courses to Industrial Arts teacher education majors at the college or university level.

These statements were provided with four degrees of answers as follows:

1. Yes, definitely
2. Yes, but with some reserve
3. Yes, but with only about 50% agreement
4. No, definitely

A tabulation of the selections chosen by the respondents participating in this survey follows.

The first statement reading, "All undergraduates who are preparing to teach a laboratory course in metals should have a basic welding course," was chosen for the purpose of asking the respondents to indicate the importance of a welding course for Industrial Arts majors who may be teaching a metals laboratory. For the first time in this survey, 91 percent of the participants as shown in Table XII agreed on the same selection. This group of participants selected the response, "Yes, definitely" that a basic welding course should be required for those individuals preparing to teach a metals laboratory. This response probably involves some bias in view of the fact that this survey was sent to instructors in the metals area. There were no teachers who indicated this requirement should be left out.

TABLE XII

All Undergraduates Who Are Preparing to Teach a Lab Course in Metals Should Have a Basic Welding Course

| | Number | Percent |
|---|---|---|
| Yes, definitely | 52 | 91 |
| Yes, but with some reserve | 4 | 7 |
| Yes, but with only about 50 percent agreement | 1 | 2 |
| No, definitely | 0 | 0 |
| Total | 57 | 100 |

The next statement, "Metallurgy should be a part of the curriculum for Industrial Arts teacher education majors," was inserted in the survey to determine the consensus of opinion among this selected group of college instructors to see if they felt a metallurgy course was important. The majority, or 57 percent, chose the second response, "Yes, but with some reserve." Table XIII, p. 24, which gives the complete information on the responses that the teachers selected, seems to indicate the group as a whole would be in favor of having metallurgy become a part of the curriculum. One of the respondents who chose "Yes, definitely," for his reply, added this comment, "Possibly not as a separate course. They should learn basic subject matter however." Only two respondents out of the 56 participating indicated that they felt that metallurgy should <u>not</u> be a part of the curriculum for Industrial Arts teacher education majors

TABLE XIII

Metallurgy Should be a Part of the Curriculum for Industrial Arts Teacher Education Program

| | Number | Percent |
|---|---|---|
| Yes, definitely | 13 | 23 |
| Yes, but with some reserve | 32 | 57 |
| Yes, but with only about 50 percent agreement | 9 | 16 |
| No, definitely | 2 | 4 |
| Total | 56 | 100 |

The next statement examines aspects of the curriculum. Specifically it reads: "Metallurgy as a specific course is a part of our Industrial Arts teacher education program." The response to this statement indicated that 17 percent of the group that participated in the study have metallurgy as a required course, while 37 percent do not have the metallurgy course listed in the curriculum for the Industrial Arts teacher education program. Twenty-four of the 52 respondents who did not give a definite "yes" or "no answer may have courses containing metallurgical theory but are not as specific about their being a part of their program. See full details in Table XIV, p. 25.

TABLE XIV

Metallurgy as a Specific Course Is a Part of Our Industrial Arts Teacher Education Program

| | Number | Percent |
|---|---|---|
| Yes, definitely | 9 | 17 |
| Yes, but with some reserve | 12 | 23 |
| Yes, but with only about 50 percent agreement | 12 | 23 |
| No, definitely | 19 | 37 |
| Total | 52 | 100 |

Welding courses require development of skill and manipulation according to the teacher educators. Confirmation of this can be seen in Table XV, p. 26, which involves the statement, "Welding is a course that requires development of skill and manipulation. The response to this statement indicates that 72 percent of the participants say "yes, definitely," that a welding course requires development of skill and manipulation. None of the 57 college teachers participating in the survey believed that welding courses did not require the development of skill and manipulation.

TABLE XV

Welding Is a Course That Requires Development of Skill and Manipulation

| | Number | Percent |
|---|---|---|
| Yes, definitely | 41 | 72 |
| Yes, but with some reserve | 12 | 21 |
| Yes, but with only about 50 percent agreement | 4 | 7 |
| No, definitely | 0 | 0 |
| Total | 57 | 100 |

The statement in the survey, "Welding is a course that requires heavy emphasis upon related theory," was used to determine how important the study of related theory is as evaluated within the framework of this study by the participants. According to the information in Table XVI, p. 27, the group did not strongly agree that "Welding is a course that requires heavy emphasis upon related theory," as 30 percent of the respondents chose, "Yes, definitely" and 37 percent chose "Yes, but with some reserve." The next 28 percent were much less certain that "Welding is a course that requires heavy emphasis upon related theory," since they selected "Yes,

but with only about 50 percent agreement. Five percent said "No, definitely," that heavy emphasis on related theory should not be a part of the preparation of people to teach college level welding courses.

TABLE XVI

Welding Is a Course That Requires Heavy Emphasis on Related Theory

| | Number | Percent |
|---|---|---|
| Yes, definitely | 17 | 30 |
| Yes, but with some reserve | 21 | 37 |
| Yes, but with only about 50 percent agreement | 16 | 28 |
| No, definitely | 3 | 5 |
| Total | 57 | 100 |

The participants' response to the statement, "Welding as taught to the Industrial Arts teacher education major is a course that requires heavy emphasis upon principles such as physics, mathematics, and chemistry," indicates the respondents feel physics, mathematics, and chemistry need not be heavily emphasized when welding is taught to the Industrial Arts teacher educator. As indicated on Table XVII, p. 28, seven percent agreed "Yes, definitely,"

that it should be a part of the background of Industrial Arts teacher educators, while 26 percent indicated "No, definitely," that it need not be a part of their background. A mild attitude toward this principle is indicated by the large group indicating considerable reserve in this matter.

TABLE XVII

Welding as Taught to the Industrial Arts Teacher Education Major Is a Course That Requires Heavy Emphasis Upon Principles such as Physics, Mathematics, and Chemistry

| | Number | Percent |
|---|---|---|
| Yes, definitely | 4 | 7 |
| Yes, but with some reserve | 14 | 25 |
| Yes, but with only about 50 percent agreement | 24 | 42 |
| No, definitely | 15 | 26 |
| Total | 57 | 100 |

The statement, "Industrial Arts teacher education majors who have taken a college level welding course should have enough knowledge to explain the following metallurgical terms," was placed next in the survey. Following this statement were seven terms; each of these

terms is to involve the opinion of the respondents as to whether or not they believed that a student should be able to explain the terms after having had a first course in welding. A second category involved students having completed a second course in welding, and again the respondents were asked to indicate whether they thought the Industrial Arts teacher education majors should be able to explain the terms involved after completing a second welding course. Finally, they were asked to indicate whether or not the Industrial Arts teacher education majors should be able to explain the terms after having completed a course in metallurgy. The following pages and tables present the data gathered concerning these statements of metallurgical terms.

The response to the metallurgical term, "The three common space lattice formations," seems to indicate that most of the welding instructors would expect students to be able to explain this term only after having had a course in metallurgy. As indicated in Table XVIII, p. 30, 28 percent of the respondents feel this principle should be mastered by students completing the first welding course. Forty-three percent of the respondents feel that

TABLE XVIII

The Three Common Space Lattice Formations

| Concept Understanding | Completing 1st Course Number | Completing 1st Course Percent | Completing 2nd Course Number | Completing 2nd Course Percent | Completing Metallurgy Number | Completing Metallurgy Percent |
|---|---|---|---|---|---|---|
| Yes, definitely | 11 | 28 | 12 | 43 | 28 | 80 |
| Yes, but with some reserve | 10 | 25 | 7 | 25 | 5 | 14 |
| Yes, but with only about 50 percent agreement | 9 | 22 | 4 | 14 | 2 | 6 |
| No, definitely | 10 | 25 | 5 | 18 | 0 | 0 |
| Totals | 40 | 100 | 28 | 100 | 35 | 100 |

those completing a second course in welding should be able to explain "The three common space lattice formations." From this and the additional data on Table XVIII, p. 30, it can be assumed that a majority of college level welding instructors feel that a course in metallurgy is necessary in order to expect students to be prepared to explain "The three common space lattice formations" to others.

The next metallurgical term reads as follows: "The Iron-Carbon Equilibrium diagram." Table XIX, p. 32, shows 34 percent of the respondents indicating that they were of the opinion that beginning welding students would not have enough knowledge to explain this term. However, only six percent of the respondents estimated that those completing a second course in welding would be unable to explain "The Iron-Carbon Equilibrium diagram." Further, 74 percent of the participants felt that after a course in metallurgy, students should be able to explain "The Iron-Carbon Equilibrium diagram."

Table XX, p. 33, was constructed to show the opinion of the participants in respect to this metallurgical term: "Interstitial and substitutional solid solutions." This table gives evidence that those teachers participating in

TABLE XIX

The Iron-Carbon Equilibrium Diagram

| Concept Understanding | Completing 1st Course Number | Completing 1st Course Percent | Completing 2nd Course Number | Completing 2nd Course Percent | Metallurgy Number | Metallurgy Percent |
|---|---|---|---|---|---|---|
| Yes, definitely | 6 | 17 | 10 | 35 | 28 | 74 |
| Yes, but with some reserve | 10 | 29 | 7 | 24 | 6 | 16 |
| Yes, but with only about 50 percent agreement | 7 | 20 | 10 | 35 | 2 | 5 |
| No, definitely | 12 | 34 | 2 | 6 | 2 | 5 |
| Total | 35 | 100 | 29 | 100 | 38 | 100 |

TABLE XX

Interstitial and Substitutional Solid Solutions

| Concept Understanding | Completing 1st Course Number | Completing 1st Course Percent | Completing 2nd Course Number | Completing 2nd Course Percent | Completing Metallurgy Number | Completing Metallurgy Percent |
|---|---|---|---|---|---|---|
| Yes, definitely | 1 | 3 | 2 | 9 | 25 | 61 |
| Yes, but with some reserve | 1 | 3 | 10 | 45 | 10 | 24 |
| Yes, but with only about 50 percent agreement | 12 | 42 | 9 | 41 | 4 | 10 |
| No, definitely | 15 | 52 | 1 | 5 | 2 | 5 |
| Total | 29 | 100 | 22 | 100 | 41 | 100 |

the study believe that "Interstitial and substitutional solid solutions" would be too difficult to explain for both the students having completed the first and second courses in welding. This is evidenced by the fact that only one participant from a total of 29 indicated beginning welding students might be expected to possess enough knowledge to explain this statement.

Only two participants out of the total of 22 agreed that students completing the second welding course should possess enough knowledge to explain "Interstitial and substitutional solid solutions." This would indicate that neither the student having taken the first course nor the student having taken the second course in welding could be expected to explain this metallurgical term to others in the opinion of the respondents. A large portion of the college welding instructors who responded were doubtful that students having completed a second welding course would be able to explain "Interstitial and substitutional solid solutions."

Since 61 percent of the participants have indicated "Yes, definitely" and only five percent indicated "No, definitely" after the students have completed a course in

metallurgy, this would tend to indicate that fewer than three-fourths of the students taking metallurgy might be expected to have the knowledge to explain "Interstitial and Substitutional solid solutions."

The next metallurgical term reads: "The Stress-Strain Diagram for structural steel." The response from the participants as shown in Table XXI, p. 36, indicates that five respondents of the 38 answering this statement, or 13 percent, feel that students completing the first welding course should have enough knowledge to be able to explain this diagram. Seven respondents of the thirty participating, or 23 percent, indicated in this study that students completing the second welding course should have enough knowledge to be able to explain this diagram. However, it was not until the student had taken both welding courses and a metallurgy course that a majority of the participants or 76 percent indicated "Yes, definitely" that the student should have enough knowledge to explain the "The Stress-Strain Diagram."

More than one-third, or 35 percent, of the respondents believed that students having completed the first welding course would not have enough knowledge to explain

TABLE XXI

Explanation of the Stress-Strain Diagram for Structural Steel

| Concept Understanding | Completing 1st Course Number | Completing 1st Course Percent | Completing 2nd Course Number | Completing 2nd Course Percent | Completing Metallurgy Number | Completing Metallurgy Percent |
|---|---|---|---|---|---|---|
| Yes, definitely | 5 | 13 | 7 | 23 | 26 | 76 |
| Yes, but with some reserve | 10 | 26 | 11 | 35 | 6 | 18 |
| Yes, but with only about 50 percent agreement | 10 | 26 | 9 | 29 | 0 | 0 |
| No, definitely | 13 | 35 | 4 | 13 | 2 | 6 |
| Total | 38 | 100 | 31 | 100 | 34 | 100 |

this term. The opinion of 13 percent of the respondents indicated that students completing the second welding course could not explain this term. Only two respondents out of a total of 34 felt that "The Stress-Strain Diagram for structural steel" could not be explained by students completing the course in metallurgy.

The "Time-Temperature-Transformation diagram" is the next item of the survey. Table XXII, p. 38, reveals that 35 percent of the respondents do not feel that students completing the first course would have enough knowledge to explain this diagram. Only two respondents indicated that students completing the first welding course would have enough knowledge to explain this diagram. Of the 33 responses tabulated for students completing the second welding course, nine percent of the respondents indicated these students would not have the knowledge to explain this diagram, while 30 percent indicated the students should have the knowledge to explain the "Time-Temperature-Transformation diagram." The respondents were in closer agreement for the students completing the metallurgy course, which is shown by 88 percent saying, "Yes, definitely" that these students should have the knowledge to

TABLE XXII

The Time-Temperature-Transformation Diagram

| Concept Understanding | Completing 1st Course Number | Completing 1st Course Percent | Completing 2nd Course Number | Completing 2nd Course Percent | Completing Metallurgy Number | Completing Metallurgy Percent |
|---|---|---|---|---|---|---|
| Yes, definitely | 2 | 6 | 10 | 30 | 29 | 88 |
| Yes, but with some reserve | 9 | 27 | 15 | 46 | 2 | 6 |
| Yes, but with only about 50 percent agreement | 11 | 32 | 5 | 15 | 2 | 6 |
| No, definitely | 12 | 35 | 3 | 9 | 0 | 0 |
| Total | 34 | 100 | 33 | 100 | 33 | 100 |

be able to explain this diagram. No participants indicated this diagram would be too difficult for students having completed a course in metallurgy.

The next item involves the microstructure of steel and is stated as the "Recrystallization of cold rolled steel." The response to this term reflects the opinion of the participants which indicates they believe the student would apparently not have the knowledge to explain the "Recrystallization of cold rolled steel" to others until after completing a second welding course and a course in metallurgy. As indicated in Table XXIII, p. 40, 13 percent of the respondents believe that a student having completed the first welding course should be able to explain "Recrystallization of cold rolled steel." Twenty percent of the respondents believe that a student completing the first welding course would not have the knowledge to explain this term.

For those students completing the second welding course, 25 percent of the respondents feel these students should be able to explain the "Recrystallization of cold rolled steel." A large group of respondents, or 65 percent, indicated an unwillingness to be as precise as

TABLE XXIII

Recrystallization of Cold Rolled Steel

| Concept Understanding | Completing 1st Course Number | Completing 1st Course Percent | Completing 2nd Course Number | Completing 2nd Course Percent | Completing Metallurgy Number | Completing Metallurgy Percent |
|---|---|---|---|---|---|---|
| Yes, definitely | 5 | 13 | 8 | 25 | 29 | 88 |
| Yes, but with some reserve | 11 | 31 | 14 | 43 | 3 | 9 |
| Yes, but with only about 50 percent agreement | 12 | 36 | 7 | 22 | 1 | 3 |
| No, definitely | 7 | 20 | 3 | 10 | 0 | 0 |
| Total | 35 | 100 | 32 | 100 | 33 | 100 |

"Yes, definitely," or "No, definitely," for students completing the second welding course.

After the Industrial Arts teacher education majors have completed the metallurgy course, 88 percent of the respondents indicated these students should be able to explain "Recrystallization of cold rolled steel."

The last item in Part II reads as follows, "Hardening heat treatment of carbon steel." Table XXIV, p. 42, indicates that 50 percent of the respondents said, "Yes, definitely" that students having completed the first course in welding could explain "Hardening heat treatment of carbon steel." Seventy-five percent of the respondents said that students having completed the second course in welding should have enough knowledge to explain this term. Ninety-seven percent of the respondents indicated that students completing the metallurgy course should have enough knowledge to explain "Hardening heat treatment of carbon steel." Only two respondents selected "No, definitely." These responses occurred for students completing the first welding course.

TABLE XXIV

Hardening Heat Treatment of Carbon Steel

| Concept Understanding | Completing 1st Course Number | Completing 1st Course Percent | Completing 2nd Course Number | Completing 2nd Course Percent | Completing Metallurgy Number | Completing Metallurgy Percent |
|---|---|---|---|---|---|---|
| Yes, definitely | 20 | 50 | 21 | 75 | 34 | 97 |
| Yes, but with some reserve | 12 | 30 | 6 | 21 | 0 | 0 |
| Yes, but with only about 50 percent agreement | 6 | 15 | 1 | 4 | 1 | 3 |
| No, definitely | 2 | 5 | 0 | 0 | 0 | 0 |
| Total | 40 | 100 | 28 | 100 | 35 | 100 |

Part III. Part III contains a group of questions in which the respondents were asked to indicate how much time during the welding course should be allocated to theory and how much time for skill and manipulative practice.

The first question of Part III was stated as follows: "What percent of the time should be used in lecture and discussion of related study?" The largest group of respondents had the opinion that 25 percent of the time should be used for lecture and discussion. Four of the respondents indicated the lowest time, or 15 percent, while three of the teachers selected 75 percent as being, in their opinion, the percent of time that should be used in lecture and discussion of related study. Computations from Table XXV show that 31 percent represents the average amount of time that should be spent for lecture and discussion of related study.

TABLE XXV

What Percent of the Time Should be Used in Lecture and Discussion of Related Study?

| Percent | 0 | 15 | 25 | 40 | 55 | 65 | 75 | 100 |
|---|---|---|---|---|---|---|---|---|
| Number | 0 | 4 | 35 | 14 | 1 | 1 | 3 | 0 = 58 |

The reply to the next question, "What percent of the

time should be used in skill development or practical application?" indicated the largest group of respondents, or 29 of the 58 participating, have chosen 75 percent as representing the time they would allocate for skill development and practical application. The least amount of time (25 percent) spent for skill development and practical application was selected by four respondents. The respondents had the opinion that an average of 66 percent of the time should be spent for skill development or practical application. Refer to Table XXVI for full details.

TABLE XXVI

What Percent of the Time Should be Used in Skill Development or Practical Application?

| Percent | 0 | 15 | 25 | 40 | 55 | 65 | 75 | 100 |
|---|---|---|---|---|---|---|---|---|
| Number | 0 | 0 | 4 | 5 | 9 | 11 | 29 | 0 = 58 |

Question three of this part of the survey was, "What percent of the time should be spent during advanced courses performing teaching principles as would be used on the high school level?" This question had the greatest spread of answers given in Part III. One respondent indicated that he spent 100 percent of the time in advanced

courses performing teaching principles as would be used on the high school level, while five respondents indicated none of their time would be spent in advanced courses performing teaching principles as would be used on the high school level. Thirteen of the respondents indicated as their selection that 25 percent of the time should be spent during advanced courses performing teaching principles as would be used on the high school level, while 17 respondents selected 15 percent of the time.

The average time that should be spent during advanced courses performing teaching principles as they would be used on the high school level computed from Table XXVII was 26 percent.

TABLE XXVII

What Percent of the Time Should be Spent During Advanced Courses Performing Teaching Principles as Would be Used on the High School Level?

| Percent | 0 | 15 | 25 | 40 | 55 | 65 | 75 | 100 |
|---|---|---|---|---|---|---|---|---|
| Number | 5 | 17 | 13 | 9 | 2 | 0 | 5 | 1 = 52 |

The next statement of this part of the survey asks this question, "What percent increase of time has been added to lecture covering new welding processes since the

of time, while one teacher reported that 75 percent increase of time had been added to his lecture covering new welding processes since the World War II period. The largest group, or 28 of the 54 respondents, reported that 15 percent increase of time had been added to lecture covering new welding processes since the World War II period.

Computations from Table XXVIII revealed the average increase in time added to lecture covering new welding processes since the World War II period was 22 percent.

TABLE XXVIII

What Percent Increase of Time Has Been Added to Lecture Covering New Welding Processes Since the World War II Period?

| Percent | 0 | 15 | 25 | 40 | 55 | 65 | 75 | 100 |
|---|---|---|---|---|---|---|---|---|
| Number | 4 | 28 | 12 | 7 | 0 | 2 | 1 | 0 = 54 |

The last question of this part of the survey reads as follows: "What percent increase of time has been added in skill development or practical application covering new welding processes since the World War II period?" Table XXIX, p. 47, shows that 14 respondents indicated no

increase of time in skill development or practical application covering new welding processes since World War II. Two respondents indicated that a 65 percent increase of time has been added in skill development or practical application covering new welding processes since the World War II period. Computations from the table show that 18 percent is the average increase of time added in skill development or practical application covering new welding processes since the World War II period as indicated by the respondents.

TABLE XXIX

What Percent Increase of Time Has Been Added in Skill Development or Practical Application Covering New Welding Processes Since the World War II Period?

| Percent | 0 | 15 | 25 | 40 | 55 | 65 | 75 | 100 |
|---|---|---|---|---|---|---|---|---|
| Number | 14 | 22 | 8 | 4 | 2 | 2 | 0 | 0 = 52 |

Part IV. This part of the survey asked the respondents for information concerning welding and metallurgy textbooks used for courses given to Industrial Arts teacher education majors. The Appendix (p. 70) contains the complete list of books which were used by the respondents for reference and as textbooks for courses in

welding and metallurgy. An analysis of this list of books was made to find the book or books most frequently used in the welding courses and the metallurgy courses.

Textbooks used by more than three respondents in their welding and metallurgy courses appear in Table XXX, p. 49, and are listed in two categories as follows:

1. Those textbooks which the respondents indicated were required for the course.

2. Those textbooks and references which the respondents used but did not require.

A further division was instrumented for clarity according to where these textbooks were used:

1. Textbooks used by the instructor of the introductory welding course for teacher education majors.

2. Textbooks used in the advanced welding courses given for teacher education majors.

3. Textbooks used in the metallurgy courses open to Industrial Arts teacher education majors.

Three of the most frequently used textbooks and reference books for courses in welding are:

1. Modern Welding Practices, Althouse and Turnquist.
2. The Oxyacetylene Handbook, Linde.
3. Metals and How to Weld Them, Jefferson and Woods.

The most frequently used textbook for metallurgy is: Elementary Metallurgy, Frier.

Part IV of the survey also asked for an outline of

TABLE XXX

The Most Frequently Used Textbooks As Indicated by the Teachers Participating in the Survey

| Title of Book | Author | 1st Welding Course Req'd. | 1st Welding Course Not Req'd. | 2nd Welding Course Req'd. | 2nd Welding Course Not Req'd. | Metallurgy Course Req'd. | Metallurgy Course Not Req'd. |
|---|---|---|---|---|---|---|---|
| Metals and How to Weld Them | Jefferson & Woods | 4 | | 5 | | | |
| Elementary Metallurgy | Frier | 1 | | | | 6 | |
| The Oxyacetylent Handbook | Linde | 9 | 7 | 2 | | | |
| Welding Skills and Practices | Giachino, Weeks & Brune | 5 | | 1 | | | |
| Electric Arc Welding | Austin | 2 | 2 | | | | |
| Modern Welding Practices | Althouse Turnquist | 11 | 2 | 1 | 1 | | |
| Welding Handbook | Welding Handbook Committee | | 1 | 2 | 2 | | |

TABLE XXX Continued

| Title of Book | Author | 1st Welding Course Req'd. | 1st Welding Course Not Req'd. | 2nd Welding Course Req'd. | 2nd Welding Course Not Req'd. | Metallurgy Course Req'd. | Metallurgy Course Not Req'd. |
|---|---|---|---|---|---|---|---|
| Arc Welding Lessons for School Shop & Farm | Kugler | 6 | 1 | | | | |
| Welding Processes and Procedures | Morris | 4 | | | | | |
| Metalwork Technology and Practice | Ludwig | 4 | | | | | |

the course of studies concerning welding students majoring in Industrial Arts education. Twenty-three outlines were examined to find areas of study most common to the courses taught by teacher educators. Areas common to all courses of study were as follows:

1. Oxyacetylene cutting
2. Oxyacetylene welding and brazing
3. Metal-arc welding
4. Resistance welding
5. Heat treatment
6. Testing of welded fabrications

Those areas of welding in these outlines mentioned less frequently were: (a) analysis and control of welding defects, (b) weldability of metals other than carbon steel or cast iron, and (c) strength comparisons of joints and structures.

In view of the great variation and character of these outlines, further study and analysis of them was deemed impractical.

# CHAPTER IV

# SUMMARY, OBSERVATIONS AND RECOMMENDATIONS

## Summary of Study

This study was made to determine how extensive a metallurgical background is needed by those persons teaching welding courses to Industrial Arts teacher education majors at the college or university level.

Of the group of eleven terms describing aspects of metallurgy only four of the terms were selected by 50 percent or more of the respondents who agreed that this is a very important part of the information contributing to the metallurgical background of the individual teaching welding courses to the Industrial Arts teacher education majors. These four terms are listed below:

1. Theory of metal joining
2. Theory of metal working
3. Principles of heat treatment
4. Methods and principles of cutting

From the group of 11 terms mentioned above, the four terms which were indicated by the greatest number of respondents to be too complex for use as information contributing to the background of the individual teaching welding courses to the Industrial Arts teacher education

majors are:

1. Metals as they exist in the atomic state
2. State and behavior of crystal in structure
3. Destructive and non-destructive testing
4. Solidification of metals and alloys

Most of the college and university teachers participating in the survey (91 percent) believe that "All undergraduates who are preparing to teach a laboratory course in metals should have a basic welding course."

Thirty-seven percent of the 58 respondents indicated that metallurgy as a specific course was not part of their Industrial Arts teacher education program; however, only four percent indicated that they believed that metallurgy should not be a part of the curriculum.

Almost three-fourths of those participating in the survey agree that the development of skills and manipulation should be a part of the requirements of a welding course.

Thirty percent indicated an answer of "Yes, definitely" to the statement: "Welding is a course that requires heavy emphasis upon related theory."

In response to the statement "Welding as taught to the Industrial Arts teacher education major is a course

that requires heavy emphasis upon principles such as physics, mathematics, and chemistry," only seven percent agreed that these principles should be emphasized as indicated by their having selected the answers.

The greatest number of respondents indicated that students who have completed the first welding course should have enough knowledge to be able to explain the following terms to others:

1. Hardening heat treatment of carbon steel
2. The three common space lattice formations

Further the greatest number of respondents indicated that they believe that students who have completed the second welding course should have enough knowledge to be able to explain the following terms to others:

1. Hardening heat treatment of carbon steel
2. The three common space lattice formations

As indicated by the greatest number of respondents, the three terms which Industrial Arts teacher education majors should be able to explain after having completed a metallurgy course are as follows:

1. Hardening heat treatment of carbon steel
2. The Time-Temperature-Transformation Diagram
3. Recrystallization of cold rolled steel

The participants indicated that about 30 percent of

the total time devoted to a welding course should consist of lecture and discussion of related theory and that about 66 percent of the time should be used in skill development or practical application of welding processes.

The study revealed that the participants indicated that 26 percent of the time during the advanced welding course should be spent performing teaching principles as would be used in teaching welding on the high school level.

Teachers participating in this survey have indicated that there has been an increase of time added to both lecture and skill development or practical application covering new welding processes since World War II. When asked what percent increase of time has been added, the participants report about 22 percent has been added to lecture involving new welding processes, and 18 percent increase of time has been added in skill development or practical application covering new welding processes since World War II.

The textbook that is most frequently required by the teacher educators conducting the beginning welding course was indicated by the respondents to be, Modern Welding Practices by A. D. Althouse and C. H. Turnquist. It was

further indicated that the most frequently used textbook by the teacher educators in the advanced welding course is Metals and How to Weld Them by Theodore B. Jefferson and Gorham H. Woods. The metallurgy course textbook most frequently used by the respondents in this study was Elementary Metallurgy by William T. Frier.

An examination of the study outlines received from the respondents revealed 80 percent of the 23 outlines examined contained specific information related to the following areas of welding:

1. Oxyacetylene cutting
2. Oxyacetylene welding and brazing
3. Metal-arc welding
4. Resistance welding
5. Heat treatment
6. Testing of welded fabrications

The areas of study least mentioned by the respondents in their outlines are as follows:

1. Analysis and control of welding defects
2. Weldability of metals other than carbon steel or cast iron
3. Strength comparisons of joints and structures

## Observations

The following observations made by the writer come as a direct result of this survey.

Apparently there are welding teachers who participated in this questionnaire-opinionnaire survey who did not understand some of the technical principles or statements. Especially noticeable is the group of participants who indicated that the principle, "Destructive and non-destructive testing" was too complex for use as information which should be a part of the background of teacher educators who teach welding courses. Yet one of the basic requirements of the college welding instructor in teacher education courses is the ability to recognize welding defects.

Also there appeared to be some inconsistency in answers provided by the respondents. Only a very small percentage of the respondents indicated a reluctance to emphasize the principle, "Heat treatment techniques," as a necessary part of the background of the welding teacher educator. More than 30 percent of the participants indicated that they believed that Industrial Arts teacher education majors who have completed the beginning welding course would not have enough knowledge to explain two of the basic heat treating principles, which are:

1. The Iron-Carbon Equilibrium Diagram
2. The Time-Temperature-Transformation Diagram

It is interesting to note that the results of this survey indicated 29 of the 58 teachers participating in this study reported they spend 75 percent of the class time for skill development or practical application of welding processes. This tends to indicate that some of those participating in this study consider welding classes to be laboratory courses only. From this standpoint it is surprising that so many respondents believed so much emphasis should be placed on principles of welding metallurgy.

## Recommendations

These recommendations are made in view of the evidence gathered by the survey:

1. That a study be made of what recognized authorities have to say about technical diagrams such as the Iron-Carbon Equilibrium Diagram and the Time-Temperature-Transformation Diagram with the view of determining the degree to which these diagrams should be included in welding courses for Industrial Arts teachers of welding.

2. That a study be made throughout the United States to determine how the college welding class for teacher

educators is divided between theory and practice.

3. That a study be made to determine whether or not the ratio of theory to practice as exists in welding courses for teacher educators will achieve the greatest educational advancement.

4. That research be conducted which concerns all Industrial Arts teachers teaching welding courses on the college level in the United States to examine various aspects of the knowledge of metallurgy these teachers possess at the present time in relation to what recognized educators feel teachers should possess.

5. That a study be made of the comprehensive testing program, carried out by industry, of welded fabrications to see if a simple program of weld testing could be adopted to college and university curricula as a means of improving the teacher education program in welding.

# BIBLIOGRAPHY

1. American Welding Society. Welding handbook, fundamentals of welding. 5th ed. New York, 1962. 11.34 p.

2. Enderby, D. R. A study of Industrial Arts programs of the teacher training institutions of Oklahoma to determine if the teachers of Industrial Arts in high schools of Oklahoma are receiving adequate training. Master's thesis. Denton, North Texas State College, 1950, 82 numb. leaves.

3. Guy, Albert G. Elements of physical metallurgy. Reading, Massachusetts, Addison-Wesley, 1956. 296 p.

4. VanArsdale, Gordon D. Welding as a medium for Industrial Arts. Master's thesis. Corvallis, Oregon State College, 1947. 188 numb. leaves.

# APPENDIX

CITIES AND STATES INCLUDED IN THE SURVEY

WASHINGTON: Seattle, Bellingham, Pullman, College Place, Cheney, Ellensberg.

UTAH: Logan, Provo.

TEXAS: Stephenville, College Station, San Marcos, Abilene, Huntsville, Prairie View, Denton, Long View.

MONTANA: Bozeman, Havre.

NEBRASKA: Kearney, Peru, Lincoln.

WYOMING: Larmie.

OKLAHOMA: Stillwater, Alva, Goodwell, Durant, Ada, Wilburton, Tishomingo, Tahlequah.

SOUTH DAKOTA: Springfield, Sioux-Falls.

NORTH DAKOTA: Ellendale, Grand Forks.

MISSOURI: Kirksville, Springfield, Columbia, Jefferson City.

MINNESOTA: Winona, Duluth, Minneapolis, St. Cloud, Morrhead, Mankato, Bemidji.

IOWA: Le Mars.

COLORADO: Gunnison, Fort Collins, Alamosa.

ARIZONA: Flagstaff, Tempe.

ARKANSAS: Conway, Fayetteville.

LOUISIANA: College Station, Natchitoches, Baton Rouge.

KANSAS: Wichita, McPherson, Manhattan, Emporia, Hays Pittsburg, North Newton.

CALIFORNIA: Chico, Fresno, Arcata, Long Beach, Los Angeles, Angwin, San Diego, San Jose, San Francisco.

## INDIVIDUAL COMMENTS

Forging and Heat-Treatment of Metals, text by Rusinoff. "The above is not a metallurgy course, but brings in some metallurgy."

"At present time we do not offer a course in metallurgy, it is proposed."

"We are just now trying to beef up an all manipulative general metals approach. We anticipate moving more into the theory you discuss but still feel an obligation to the great percentage of our students who will teach in the public school."

"Our advanced courses are chiefly for welding technology majors."

"We are just in the process of starting a metallurgy course. It has just been added to the catalog."

"We do not offer welding as a separate course--only as a service area for our metals."

"No welding offered here until next year."

"We do not have a specific course in metallurgy in the Teacher Ed. curriculum."

"Our majors could possibly take engineering courses in metallurgy but it is not required and I don't know what texts are used in their courses."

"Welding is part of a general metals and is not a specific subject in the vocational sense."

"Advanced welding: A study of various arc-welding machines and equipment, rod identification, type welds, joints, positions, and testing of welds both destructive and non-destructive. Arc welding of nonferrous metals. Pipe and structural materials are also included. Projects follow if time permits."

"Objectives: More specifically, the objectives of the course are as follows: (a) To develop skills in the use and care of various types of welders and welding equipment. (b) To develop an understanding of modern industrial welding processes and practices. (c) To develop an understanding of elementary metallurgy. (d) To acquaint prospective teachers with source, specifications, and use of equipment and materials suitable for industrial arts shops in the secondary schools."

"Scope of the course: (a) Practice exercises in oxy-acetylene, arc, resistance, and inert-gas welding. (b) Plan, construct, and evaluate projects that incorporate welding processes as a means of fabrication. (c) Assigned readings relating to laboratory work, materials, processes, and industrial practices. (d) Films on welding equipment and processes. (e) Reports by students, problems, and tests."

"Course objective: The purpose of this course is (a) to teach the basic process of electric welding, (b) acquaint the student with the tools, materials, terms, and symbols used in the welding industry, (c) develop self-confidence and initiative through the successful use of electric welding equipment, (d) bring out interest and aptitudes which may lead to occupational choice, (e) develop mechanical abilities that will aid the student economically through repair and maintenance of his own tools and machinery, (f) develop a favorable attitude towards industrial pursuits and men employed in the welding industry, (g) develop good workmanship through the use of good work habits, (h) teach safety through safety practice, (i) give experience in reading working drawings, especially working drawings as developed for the welding industry."

"Have no separate class as yet but are trying to instigate one."

"Only one course in welding presently being offered. (a) History of Welding (b) Survey of Welding Processes (c) Principles of Oxy-acetylene Welding (d) The Electric Arc and Its Application to Welding (e) Equipment and Materials Used in Welding (f) Oxygen and Arc Cutting of Metals (g) Metals and Their Weldability (h) Design and Fabrication Considerations (i) Testing and Inspection of Welds (j) Welding Terms and Their Definitions."

"No metallurgy course required. Few Ind.-Arts majors have the prerequisites for the metallurgy courses in the Engineering College."

"Metallurgy is presently taught in other metals classes and not as a separate course."

"We do not have an advanced course in welding as yet, but plan to offer one which will place emphasis on new scientific developments and theory. We plan to offer a new course in our Ind. Ed. Dept. called 'Metals Technology' or some other appropriate name, and cover as much metallurgy as we feel the student needs. This will give us more control of the course content."

"Welding, in itself, is not taught but is included as part of the general metals program and is a definite unit of the two-year vocational training program."

"Gas and Electric Welding, 1 hour credit, three hours laboratory per week. 15 weeks per semester. 40% of contact time devoted to lectures. 55% of contact time devoted to practice laboratory. Areas of study: Gas welding and equipment, practices and safety; distortion, metallurgy of ferrous alloys; gas cutting--metalizing--; preheating and post heating; manual arc welding machines; DC vs AC; resistance welding; special methods; new methods."

"Basic Course: (1) Arc welding (first position primary) (2) Electrodes (3) Metallurgy (4) Specimen testing (5) Oxy-acetylene welding (6) Bronze welding

(7) Flame cutting. Advanced Course: (1) Welding processes (2) Fields of application (3) metallurgy and engineering applications (4) Welding symbols (5) Heat treatment (6) Testing welds."

"One-fourth of a 3-hour course in Fundamentals of Metalwork is devoted to gas and arc welding combined. The regular course in welding is a 3 semester hour course involving gas and arc welding and heat treatment."

"The beginning welding course consists of oxy-acetylene (low-carbon steel welding, brazing, and cutting) and arc (flat, pad, T-bar and vertical). The course is for two hours credit and consists of three one-hour lab periods and one hour lecture period (per week). Lecture period covers related information for gas and arc welding. We feel that Industrial Arts teachers should have more welding and plan to offer an advanced course in the future to go along with our beginning welding course and technology of metals course."

REFERENCES USED TO DEFINE TECHNICAL TERMS AND CONCEPTS

1. American Society for Metals. Metals handbook. 8th ed. Metals Park, Ohio, 1961. 1300 p.

2. American Welding Society. Welding handbook. 3d ed. New York, 1950. 1651 p.

3. Brick, R. M. and Arthur Phillips. Structure and properties of alloys. New York, McGraw-Hill, 1949. 485 p.

4. Burton, Malcolm S. Applied metallurgy for engineers. New York, McGraw-Hill, 1956. 794 p.

5. Guy, Albert G. Elements of physical metallurgy. Reading, Massachusetts, Addison-Wesley, 1956. 296 p.

6. Henderson, J. G. and J. M. Bates. Metallurgical dictionary. New York, Reinhold, 1953. 396 p.

7. Jefferson, T. B. and Gorham Woods. Metals and how to weld them. Cleveland, The James F. Lincoln Arc Welding Foundation, 1962. 392 p.

8. Merriman, A. D. A dictionary of metallurgy. London, MacDonald and Evans, 1958. 401 p.

## GLOSSARY OF TERMS

The following glossary of terms is taken from the books listed in Appendix, page 66.

Atomic State: "The study of metallic structure is conveniently begun with a consideration of metal atoms. These atoms are the fundamental units that compose an actual alloy member, such as a bridge girder. Therefore, the nature of these atoms must determine all the physical, mechanical and chemical properties of the alloy." Guy (5, p. 29)

Space Lattice: "A system of equivalent points possessing the same symmetry elements and the same translations as one of the 230 different arrangements theoretically possible for atoms in crystals. The large number of space groups as compared with point groups is due to the fact that a different location in space for the same symmetry elements is possible in the former, but not in the latter." Henderson (6, p. 332)

Solid Solutions: "Metallic solid solutions are one-phase structures containing two or more elements in which concentration or temperature can be varied through a considerable range without changing the type of crystal structure of the alloy. Commercially important solid-solution alloys generally have the crystal characteristics of the element present in greatest amount . . ." Brick and Phillips (3, p. 57)

Interstitial Solid Solution: "A type of solid solution sometimes formed in alloy systems having two elements of widely different atomic sizes. Elements of small atomic size such as carbon, hydrogen and nitrogen often appear in solid metals to form this type of solid solution. The space lattice is similar to that of the pure metal and the atoms of carbon, hydrogen and nitrogen occupy the spaces or interstices between the metal atoms. The best

known example is austenite, the gamma solid solution in iron carbon alloys." Merriman (8, p. 139)

Substitutional Solid Solutions: (see solid solutions above) "In the usual substitutional type of solutions, one type of atom, the solute, is substituted for the other, the solvent, at random points on its lattice." Brick and Phillips (3, p. 57)

Stress: "The stress in a material subjected to external forces represents the intensity of the internal forces that tend to resist a change in the volume or shape of the material. It is measured by the load on the material divided by the instantaneous area over which it acts." Merriman (8, p. 343)

Strain: "A measure of the change in the size or shape of a body, referred to its original size or shape... When the term strain is used alone it usually refers to the linear strain in the direction of the applied stress." American Society for Metals (1, p. 36)

Recrystallization: "Recrystallization entails the complete formation of new and unstrained metal grains, with simultaneous elimination of previously cold-worked and distorted metal. Recrystallization is very evident because of its marked effect on mechanical properties. Strain hardening and work strengthening which resulted from cold working are largely eliminated by recrystallization, and ductility is simultaneously restored." Burton (4, p. 232)

Destructive Testing: "Tests which involve the destruction of a complete welded unit or may require specimens cut from the unit that has been selected as representative to be tested to destruction. Destructive tests supply qualitative information. They include tensile, bend, nick break, impact, fatigue, specific gravity, hardness, drift and crush test." Jefferson (7, p. 207)

Non-destructive Testing: "The group of tests used to detect defects or flaws in metals but leaving the specimen fit to perform the task for which it was made, after testing. The tests are intended to reveal both external and internal defects. The methods may be divided into the following groups: Magnetic Methods. . .Sonic Test. . . Supersonic Tests. . .Radiographic Tests. . .Fluoroscope Tests. . .and Damping Capacity Tests." Merriman (8, p. 208)

Welding Process: "A metal-joining process wherein coalescence is produced by heating to suitable temperatures, with or without the application of pressure, and with or without the use of a filler metal." American Welding Society (1, p. 23)

## TEXTBOOKS USED IN METALLURGY COURSES

1. Burton, Malcom S. Applied metallurgy for engineers. New York, McGraw-Hill, 1956. 355 p.

2. Claussen and Henry. Welding metallurgy. New York, American Welding Society, 1940.

3. Committee on Metallurgy. Engineering metallurgy. New York, Pitman Publishing Corporation, 1957.

4. DeGarmo, E. Paul. Material and processes in manufacturing. 2d ed. New York, Macmillan Company, 1962. 794 p.

5. Frier, William T. Elementary metallurgy. 2d ed. New York, McGraw-Hill, 1952.

6. Guy, Albert G. Elements of physical metallurgy. Reading, Massachusetts, Addison-Wesley, 1956. 296 p.

7. Jefferson, Theodore B. and Gorham Woods. Metals and how to weld them. Cleveland, James F. Lincoln Arc Welding Foundation, 1962. 392 p.

8. Johnson, Carl G. and William R. Weeks. Metallurgy. 4th ed. Chicago, American Technical Society, 1963.

9. Keyser, Carl A. Materials of engineering. New York, Prentice-Hall, 1956.

10. Merriman, A. D. A dictionary of metallurgy. London, England, MacDonald and Evans, 1958. 401 p.

11. Udin, Harry, Edward R. Funk and John Wulff. Welding for engineers. New York, Wiley, 1954.

TEXTBOOKS USED IN WELDING COURSES

1. Althouse, A. D. and C. H. Turnquist. Modern welding practices. Chicago, Goodheart-Wilcox, 1958.

2. Austin, John B. Electric arc welding. Chicago, American Technical Society, 1952.

3. American Welding Society. Welding handbook. 3d ed. New York, 1956.

4. Begeman, M. L. Manufacturing processes. New York, Wiley, 1957.

5. Burton, Malcom S. Applied metallurgy for engineers. New York, McGraw-Hill, 1956.

6. Doyle, Lawrence. Manufacturing processes and materials for engineers. New York, Prentice Hall, 1961.

7. Feirer, John L. General metals. New York, McGraw-Hill, 1960.

8. Giachino, Joseph W., Weeks, William R. and Elmer J. Brune. Welding skills and practices. Chicago, American Technical Society, 1952.

9. Harcourt, Robert Henry. Elementary forging practices. Peoria, Illinois, Manual Arts Press, 1938.

10. Jefferson, Theodore B. and Gorham H. Woods. Metals and how to weld them. Cleveland, The James F. Lincoln Arc Welding Foundation, 1962.

11. Jefferson, Theodore B. The welding encyclopedia. Morton Grove, Illinois, Welding Engineer Publications, 1961.

12. Jennings, Royalston F. General shop gas and A.C. arc welding and cutting. Bloomington, Illinois, McKnight & McKnight, 1959.

13. Kugler, Harold R. Arc welding lessons for school and farm shop. Cleveland, James F. Lincoln Arc Welding Foundation, 1950.

14. Lincoln Electric Company. New lessons in arc welding. Cleveland, James F. Lincoln Foundation, 1957.

15. Lincoln Electric Company. Manual of instruction for arc welding. Cleveland, James F. Lincoln Arc Welding Foundation, 1957.

16. Lincoln Electric Company. Procedure handbook of arc welding design and practice. Cleveland, James F. Lincoln Arc Welding Foundation, 1957.

17. Linde Air Products Company. The oxyacetylene welders handbook. New York, 1947.

18. Linde Air Products Company. Welding and cutting manual. New York, 1949.

19. Ludwig, Otto A. Metalwork technology and practice. New York, McKnight & McKnight, 1958.

20. Morris, Joe, L. Welding processes and procedures. Englewood Cliffs, New Jersey, Prentice-Hall, 1954.

21. Morris, Joe, L. Welding principles for engineers. New York, Prentice-Hall, 1953.

22. Parker, Marvin L. Farm arc and acetylene welding. New York, McGraw-Hill, 1958.

23. Rossi, Boniface E. Welding engineering. New York, McGraw-Hill, 1954.

24. Rossi, Boniface E. Welding and its application. New York, McGraw-Hill, 1951.

25. Rossi, Boniface E. Manual of instruction in welding and cutting. New York, McGraw-Hill, 1941.

26. Sacks, R. J. Theory and practice of arc welding. New York, D. Van Nostrand, 1960.

27. Smith, Robert. Forging and welding. New York, Taplinger Publishing Company, 1958.

28. Steiri, Emanuele. Basic welding principles. New York, Prentice-Hall, 1953.

29. Umowski, Joseph S. Ferrous metallurgy. Chicago, American Technical Society, 1960.

February 11, 1963

Dear Sir:

In an effort to improve the teacher education curriculum for industrial arts teachers, a study is being made to determine the extent to which metallurgy contributes to the background of college and university teachers presently engaged in the area of welding instruction.

This letter is being sent to colleges and universities geographically located west of the Mississippi River. Following this letter, a questionnaire will be mailed to those indicating a willingness to help by answering a few questions (time - 10 minutes).

If you are willing to participate, will you please write your name and address on the enclosed post card and return it immediately. A copy of the results will be sent out to all who return post cards and indicate that a summary of the results is desired.

Cordially,

L. Carl Love

L. Carl Love, Instructor
Production Technology Dept.
Oregon State University
Corvallis, Oregon

Study directed by:

Chester B. Ainsworth

Dr. Chester B. Ainsworth, Head
Department of Industrial Arts
Oregon State University
Corvallis, Oregon

## QUESTIONNAIRE

This questionnaire is part of a study to determine how extensive a metallurgical background is needed by the individual teaching welding courses to Industrial Arts teacher education majors at the college or university level. This study is aimed at both the basic and advanced courses. When answering the questions, base your choice of opinion on what you consider the present status of the problem. For the purpose of this study, a metallurgical background signifies a comprehension or understanding of metals as follows:

Metals as they exist in the atomic state
Solidification of metals and alloys
State and behavior of crystal structure
Structure and property of alloys
Production of metals
Theory of metal working
Principles of heat treatment
Theory of metal joining
Heat treating technique
Methods and principles of cutting
Destructive and non-destructive testing

## PART I

Will you please state the degree to which you consider it necessary to study the individual areas indicated below in preparation for college instruction of Industrial Arts teacher education majors. Choose from one of the four responses which precede the question by circling the desired answer. The responses will be as follows:

1. Heavy emphasis
2. Moderate emphasis
3. Light introduction
4. Too complex and should not be used

1 2 3 4 1. Metals as they exist in the atomic state
1 2 3 4 2. Solidification of metals and alloys

Cont'd next page

1 2 3 4 3. State and behavior of crystal in structure
1 2 3 4 4. Structure and property of alloys
1 2 3 4 5. Production of metals
1 2 3 4 6. Theory of metal working
1 2 3 4 7. Principles of heat treatment
1 2 3 4 8. Theory of metal joining
1 2 3 4 9. Heat treating techniques
1 2 3 4 10. Methods and principles of cutting
1 2 3 4 11. Destructive and non-destructive testing

## PART II

Please answer the following questions with the response that most closely matches how you feel about the statement. Circle one of the four responses to indicate your desired answer.

1. Yes, definitely.
2. Yes, but with some reserve.
3. Yes, but with only about 50% agreement.
4. No, definitely.

1 2 3 4 1. All undergraduates who are preparing to teach a lab course in metals should have a basic welding course.

1 2 3 4 2. Metallurgy should be a part of the curriculum for Industrial Arts teacher education majors.

1 2 3 4 3. Metallurgy as a specific course is a part of our Industrial Arts teacher education program.

1 2 3 4 4. Welding is a course that requires development of skill and manipulation.

1 2 3 4 5. Welding is a course that requires heavy emphasis upon related theory.

1 2 3 4 6. Welding as taught to the Industrial Arts teacher education major is a course that requires heavy emphasis upon principles such as physics, mathematics and chemistry.

Cont'd next page

1 2 3 4 7. It is essential to have public school teaching experience to be effective as a welding instructor in the industrial arts program.

8. Industrial Arts teacher education majors who have taken a college level welding course should have enough knowledge to explain the following terms. Please evaluate individually according to the amount of welding and metallurgy taken.

| | Completing 1st course | Completing 2nd course | Completing metallurgy course |
|---|---|---|---|
| a. The three common space lattice formations | 1 2 3 4 | 1 2 3 4 | 1 2 3 4 |
| b. The Iron-Carbon Equilibrium diagram | 1 2 3 4 | 1 2 3 4 | 1 2 3 4 |
| c. Interstitial and substitutional solid solutions | 1 2 3 4 | 1 2 3 4 | 1 2 3 4 |
| d. The Stress-Strain diagram for structural steel | 1 2 3 4 | 1 2 3 4 | 1 2 3 4 |
| e. The Time-Temperature-Transformation diagram | 1 2 3 4 | 1 2 3 4 | 1 2 3 4 |
| f. Recrystallization of cold rolled steel | 1 2 3 4 | 1 2 3 4 | 1 2 3 4 |
| g. Hardening heat treatment of carbon steel | 1 2 3 4 | 1 2 3 4 | 1 2 3 4 |

Cont'd next page

## PART III

This pertains to college welding courses for Industrial Arts teacher education majors. Please answer the questions by circling one of the underlined numbers below:

1. What percent of the time should be used in lecture and discussion of related study?

   0 15 25 40 55 65 75 100

2. What percent of the time should be used in skill development or practical application?

   0 15 25 40 55 65 75 100

3. What percent of the time should be spent during advanced courses performing teaching principles as would be used on the high school level?

   0 15 25 40 55 65 75 100

4. What percent increase of time has been added to lecture covering new welding processes since the World War II period?

   0 15 25 40 55 65 75 100

5. What percent increase of time has been added in skill development or practical application covering new welding processes since the World War II period?

   0 15 25 40 55 65 75 100

Cont'd next page

PART IV

Will you please list the texts used by the instructor of the introductory welding course given to Industrial Arts teacher education majors?

| Text | Author | Required |
|---|---|---|
| | | Yes No |
| | | Yes No |
| | | Yes No |

Will you please list the texts used by your advanced welding course given to Industrial Arts teacher education majors?

| Text | Author | Required |
|---|---|---|
| | | Yes No |
| | | Yes No |
| | | Yes No |

Will you briefly outline your study schedule for the welding course or courses given to Industrial Arts teacher education majors? (Use back side)

Will you please list the texts used by your metallurgy course which is open to Industrial Arts teacher education majors?

| Text | Author | Required |
|---|---|---|
| | | Yes No |
| | | Yes No |
| | | Yes No |