THESIS
on
THE TEACHING OF ELEMENTARY FORGING
BY THE CONTRACT METHOD

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by
Roby D. Goff
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APPROVED:

Professor of Industrial Education
In Charge of Major

Chairman of Committee on Graduate Study.
ACKNOWLEDGMENT

The author desires to express his appreciation for the valuable assistance given by Professor George E. Cox, who not only furnished the inspiration to make this study but has been always ready with suggestions and helpful criticisms. The author is also indebted to Mr. William H. Horning for much assistance in the choosing of subject-matter for the course, and for timely criticism on several of the units of instruction.
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INTRODUCTION

In the following study an attempt is made to apply the contract method of teaching to an elementary course in forging. The observation and experience of the author has led him to believe that there is an opportunity to improve upon the methods in common use. This study is the result of an attempt to develop a method whereby larger classes may be taught without seriously lowering the teaching efficiency, and without stunting either the initiative or the interest of the pupils.

The present economic condition and the rapid increase in high school attendance has forced an increase in the size of industrial arts classes. This has, in many cases, resulted in placing a premium on individual instruction, or a neglect and evasion of the individual differences of the pupils. Course outlines have been established for the mass instruction, while successful teaching of industrial arts subjects largely depends upon individual instruction. Many times the fundamental processes cannot be taught by group instruction because of the wide differences in time of application by the various pupils.

Another factor that has complicated industrial arts teaching is the trend toward a wider and wider use of worthwhile projects. In many cases this has resulted in the selecting of a "standard set" of projects that each student must make. The "sets" of projects are adapted
to the "average student". They are often too difficult for the "slow student", and not sufficiently difficult to interest and challenge the "superior student".

The individual interests of the students must be considered in so far as possible. This is quite difficult in all elementary work, but should be given due consideration. Many students have been taught laziness, and indifference by a failure to provide for their individual differences.

A course outline and a method of teaching is needed that will cause every student to work to capacity. Otherwise, teaching cannot be efficient. The incentive to work to capacity may be due to an intense interest in the project being constructed, or to a challenge set up by the method of presentation. Many other factors may enter into the creation of a driving incentive, but these two are especially important.

The method presented in this study has been developed with the hope that each student in the class may be stimulated to work to capacity. It is hoped that it may indicate a means whereby the teachers of industrial arts may perform their work more efficiently, regardless of the increasing teaching load.

The author does not consider the finding and recommendations of this study as final in any sense of the
word. Methods, like objectives and subject-matter, should be progressive. The method of teaching presented in this study is expected to challenge the student. It is hoped that it will also challenge those teachers who may come into contact with it; challenge them to give due consideration to and make the necessary provisions for, the problem of individual differences. The author will appreciate any constructive criticism which may be offered.
SECTION I

DEVELOPMENT OF THE IDEA
SECTION I
DEVELOPMENT OF THE IDEA

A. Course of Study.

The course of study presented in the Appendix is the result of seven years' experience and study. This course is designed to develop the skill necessary for successful work in the successive courses offered in Forging at the school where the author is employed.

The subject-matter of the course is based upon an analysis of the trade. The analysis was made for the purpose of determining what operations were fundamental. This was followed by a survey of many typical forge shop jobs. A further analysis of these jobs helped to determine what operations were most commonly performed and were basic to the work. The sixteen operations listed in the course are the result of this analysis, comparison, and selection. An explanation of the means used for selecting suitable projects is given later in the development of the contracts.

The statement of objectives for the course is the result of a study in the field of vocational guidance, and objectives for the whole industrial arts field. These objectives are specific and supplement the general objectives of industrial arts. They are governed by the general objectives.
The list of related informational topics is the result of a careful study and an effort to select those of greatest guidance, pupil interest, and correlation with the shop work. The selection was guided by the objectives of the course.

All parts of the course of study are affected by a psychological study of the interests, needs and varying abilities of students. An attempt has been made to put into the course that material which will be within the reach of any student and yet present unlimited fields of activity for the most capable and ambitious student.

B. Formation of the Contracts.

The contracts were drawn up after the content of the course had been determined. The contracts shown in the Appendix were developed through two years of use and experiment.

The first step in the formation of the contracts consisted of grouping the operations. The operations most commonly used were placed in the first contract. The remaining operations were placed in the second contract. The third contract is designed to offer an opportunity to apply the fundamental processes to projects that may create a personal interest. This contract offers an introduction to the advanced courses in forge work.

The second step consisted of choosing suitable projects. Factors such as difficulty, time, and student
interest had to be considered in each case. Furthermore, the projects for the first contract had to be limited according to the operations specified for the contract. Approximately two dozen projects were selected for each contract. Many of these projects were selected from the texts on forging listed in the Bibliography for this study.

The projects for each contract were divided into three groups representing three levels of difficulty and time requirement. This was accomplished by carefully analyzing each project. In many cases the projects had to be altered in order to meet the requirements set up for it. Four projects were selected for each of the three groups. In this selection an attempt was made to choose those projects that would give the necessary experiences, maintain student interest, and be sufficiently difficult to challenge the ability of any student.

The scores for the projects in each group were arbitrarily assigned. This method has given satisfactory results after much careful study and changing of the projects. An attempt was made to establish scores on a time basis. This attempt was abandoned for it was found that some students would complete a project in group three in less time than other students might complete a project in group one. Objectively establishing the scores would require a time study based on each student making
all of the projects. Furthermore, it would require scoring the results obtained by a great many students.

The informational topics listed in the course of study were divided among the three contracts. In so far as possible, topics having a direct relation to the work of the contract were chosen. The informational topic guide-sheets were developed instead of informational sheets. The guide-sheets place greater responsibility upon the student and give valuable training and experience in seeking information from a number of sources.

Two types of tests were developed for the first and second contract: one, a series of performance tests; the other, an informational test. The performance tests were developed to measure the student's ability to perform the operations or do the work. Many performance tests were tried before the ones shown in this study were selected. The first tendency was toward making them too difficult and requiring too much time. The performance tests shown in this study have been used for one year with satisfactory results.

Credit is due to Mr. H. B. Nash, and Mr. R. R. Van Duzee, co-authors of a series of standardized industrial arts tests, for the method used in scoring the performance tests. However, their method had to be revised to meet the varying needs of these tests. Special
gauges were made for more rapid and accurate scoring. An attempt was made to cover the most important operations in the contracts with the series of tests prepared for them. Further information concerning the development of scoring plans may be found by studying the directions for giving and scoring the tests. (See Appendices E & F)

The informational tests were developed from the sheets of informational test material shown as a part of each contract. The sheets present the important points of the contracts. They were developed by writing out answers to the questions given on the operation sheets, and briefly stating important factors concerning the related information in each contract. Two forms of informational tests were developed as a protection against passing test information from one class to another and as a means of checking by comparing one with the other.

No attempt has been made to establish a validity and reliability rating for the tests. The tests were developed as a class grading and teaching device. The informational tests could be developed that would give satisfactory ratings in the above factors, but since the work is largely manipulative such tests would have a limited use. Varying shop conditions prohibit extensive work in the field of manipulative testing, although the tests presented here could be used in most shops. Tests that are used must be designed to meet the conditions
prevailing in a particular shop. The reliability rating of performance tests is very low due to the lack of skill of the students. Skill is attained through much practice by workmen who are capable of doing the work. Industrial arts classes are composed of students of greatly varying ability, and the time period does not permit the development of reliable skill. In the present case, an attempt has been made to increase the reliability by giving a series of tests on different days.

C. Interpretation of the Contracts.

The following interpretation of the various parts of this study is given in order that the reader may more clearly understand the working parts of the contracts.

1. Explanation of Terms.

The term "contract" as used here implies a selected unit of work which the student must do in order to receive credit for the course. No upper or lower limit is established. Each student is relatively free to progress in each contract as he desires. The chief limiting factors are the student's ability, interest, and ambition.

The subject-matter of this course in Forging is covered by three contracts. Each contract has a definite purpose. The first two offer an opportunity for the student to develop a
degree of skill in performing the operations, and to become familiar with the topics of related information presented in the contracts. The third contract is designed to offer an opportunity to apply the information and skill acquired through the first two contracts by making projects that are likely to stimulate a personal interest. The third contract might also be interpreted as an introduction to the advanced courses in forging.

The terms "exercise", "job", and "project", are commonly used interchangeably. In this study, however, the term "project", is used to designate a unit of work that may involve either an exercise having only instructional value, or a manipulative problem of utilitarian or artistic value as well. In either case the unit of work constituting the project will include certain related information as well as the manipulative problem or exercise.

The term "grade-point", is used to designate a comparative value earned by the students for their shop work, and tests. The total grade-points for the parts of the contracts are used for determining the grades. Grade-point values are determined for each part of the contracts;
that is, for shop work, performance tests, and informational tests. These are totaled to determine the final relative standing of the members of the class.

The term "score" implies an arbitrary value in points assigned to the unit of work or projects. In the shop work the three groups of projects are scored ten, twenty, and thirty points, respectively. The various parts of the tests in a like manner are rated by scores. The scores are totaled to determine the relative grade-point distribution.

The system of grading inferred here has been found to be very convenient and fair. Operation sheets are a form of instruction sheet. "The instruction sheet that deals with operation units of instruction gives definite and specific instruction for performing the operation."¹ They consist of a written statement of the steps necessary to perform the operation, as it would be given in a demonstration. The written instructions are supplemented by

¹ R. W. Selvidge, Individual Instruction Sheets, p. 10.
sketches. The students who are progressing rapidly (the upper fourth of the class) will be able to perform the operations, in most cases without a demonstration. The demonstration supplements the operation sheets for these students. The operation sheets supplement the demonstration for the slower students. They should aid recalling the demonstration, as well as by giving additional information.

The Informational Topic Guide-Sheets furnish the student with a statement of the informational topics, and list specific references when available.

Project Cards furnish a record of all shop work. In addition to the record feature, they require the student to make an analysis of the project he chooses to make, and to plan the procedure necessary to make it. The student is placed in a position where he must think and plan. If the instructor does all of the planning, one of the greatest opportunities of teaching is being ignored.

Informational Test Material consists of a statement of the points or facts used in developing the informational tests. These points are derived from the subject-matter of the respective con-
tracts, and serve as reminders to the students to indicate the more important points of the instructional material.

2. **Shop Work.**

The shop work is the most important part of the contracts, especially from the student's point of view. The primary interest of the student is the making of projects. Each contract offers a choice of twelve projects, divided into three weighted groups as is explained in the directions to students. The scores assigned to the projects give definite value in so far as grades are concerned, and indicate something of the comparative difficulties involved. When a student has satisfactorily completed a project he has earned the score assigned and the confidence that is built up through success in one project stimulates him to attempt more complicated projects in later work. An attempt is made by means of the choices possible, to provide for individual differences. This plan permits every student to work on projects that are within his range of ability. The slower student is able to carry on his work successfully because he may choose projects that are not too difficult for him to complete in the time available. More complicated
projects are suggested for the more capable students. In all cases the choice of projects should be guided by the instructor. Projects should be chosen that can be mastered, and yet, challenge the student's ability. This offers an excellent opportunity for character building. All students may meet with success in proportion to their abilities, rather than with discouragement because of failure to keep up, or to complete the work satisfactorily, in a program of rigid requirements in exercises or projects.

The three levels of difficulty make it possible for the group to pass from one contract to the next on the basis of equal time intervals. This will undoubtedly result in greater teaching efficiency, making possible a greater use of group instruction in larger classes. The incentive of a new and equal start gives encouragement to the slower students and helps them to work to capacity in order to gain grade-points commensurate with the other students.

3. Informational Topics.

Many industrial arts teachers may be justly criticized for not incorporating in their courses a sufficient amount of informational material. This study presents an attempt to enrich the course
by the use of related information. These topics are shown on the Informational Topic Guide-Sheets of each contract. A majority of the informational topics is directly related to the work being carried on in the shop. Since the studies and the shop work are carried on at the same time the students feel that it is an essential and important part of the work.

4. **Testing.**

Testing has a three-fold purpose. First, it is an indication of the teacher's success in "putting across" the teaching material. Second, it calls attention to the most important parts of the unit of work and stimulates industry, or is a teaching device. Third, it contributes to the record of progress as an additional basis for assigning grades.

Two types of tests are used in the contracts. The first is a test designed to measure the student's ability to do the work in the shop. This test is known as a performance test. The second test is designed to measure the student's retention of the related information, or what he needs to know.

Grades that are assigned only on the basis of shop observation should be criticised. This is
especially true of elementary work carried on in large classes. The major part of industrial arts is manipulative. Some form of test should be used by which the manipulative ability of the student may be measured. Each project might be carefully measured and objectively graded. Then, if all students made the same projects, it would be possible to assign grades that would be fair to the class members on a basis of direct comparison. All students should not be required to make the same projects, however, and few teachers have sufficient time to objectively grade all projects.

The performance tests recommended consist of small exercises involving the application of operations already used, and are so designed as to take a minimum of time. All students are required to "do" these manipulative tests and consequently there is a means of making a direct comparison of work within the whole group. An attempt has been made to establish objective grading scales for these performance tests. While performance tests assist in determining grades objectively, the results of a single test are not reliable, due to the low degree of skill
developed by the students in so short a time. The author has found that the ability or skill of students appears to vary greatly from day to day. A more reliable test result may be secured by using a series of tests given on different days.

The Informational Tests are so commonly used that an interpretation is considered unnecessary.

5. Grading.

Grading involves combining the results from shop work, and the tests. Grades are established by comparison on the basis of grade-points determined as follows: The scores for each part of a contract (shop work, performance test and informational test) are totaled. These totals are arranged in a "distribution" column with the highest score at the top as shown on each record sheet (pages 25 to 37). This column is included only as a grading device and has no relation with the scores of the individual students in so far as the reading of the record sheet is concerned. Next the total scores are divided into groups approximating the curve of normal distribution. Grade-point values are assigned according to the following table.
Final grading consists of combining the grade-point values earned for the shop work, the informational test, and the performance test. The total grade-points are arranged in a distribution as previously explained, and the final grades are assigned according to the following table.

<table>
<thead>
<tr>
<th>Group</th>
<th>Grade-point value</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Shop work</td>
<td>Informational test</td>
</tr>
<tr>
<td>1 (Highest)</td>
<td>8</td>
<td>4</td>
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</table>
SECTION II

APPLICATION
SECTION II
APPLICATION

A knowledge of the contracts is necessary for an understanding of the application. The following explains the use of the various parts of the contracts, and presents a record of the work for one semester.

A. Placing the Material Before the Students.

Every possible means of reducing school expense should be used, providing teaching efficiency is not seriously lowered. Extensive use is made of mimeographed material in the schools. In some cases this has gone so far as to replace text books. Carefully prepared instructional material placed in the hands of students undoubtedly greatly increased teaching efficiency. The preparation of this material sometimes involves a considerable expense. The author has largely eliminated this expense by minimizing the use of mimeographed material in the application of the contracts. Mimeographed material is probably more convenient, and more efficient, but it is believed that the economic factor justifies the inconvenience and possible lowering of efficiency during the present economic conditions. The informational tests should be mimeographed but otherwise there will be little necessity for such in the plan presented.

Information and directions presented to the students in mimeographed form are supposedly kept by the stu-
dents where they can be used as needed. Observation shows that they are lost, left in lockers, or otherwise placed where they cannot be conveniently used. The author used two sets of instructions or charts for the shop work. These include directions for the students, blueprints of the projects, exhibits of the projects, and operation sheets. The instructional material is typed. The charts are conveniently located in the shop. They are always handy, never misplaced, and are more economical than mimeographing. Two copies of the material used for class room study are conveniently posted in the front and rear of the class room. Most of the informational tests are given by reading the questions. The parts that cannot be read are written on the blackboard or on large sheets of paper.

1. **Shop Work.**

The first step in starting a class with the contracts consists of making the class familiar with the procedure. The introductory set of instructions covers this satisfactorily. The students are then shown the charts in the shop. Each student chooses the project that he wishes to make, and fills out a project record card. Very close supervision is necessary for starting the work.

As soon as a few students have chosen their pro-
jects, and had their record cards "O.K.'d" a demonstration is given. This demonstration covers the operations necessary for making the chosen projects, and usually consists of an application of the operations to some of the projects. Additional demonstrations are given as needed. These may be given for the whole class or for any part of it.

Routine work of the class, such as checking tools, cutting stock, etc., are cared for by regularly appointed members of the class. A well-organized class procedure permits much time for individual instruction. This is made possible largely by the use of instruction sheets, and the grouping of the work into units as represented by the contracts. The organization and method presented here places upon the boy the full responsibility of having work to do. He always knows what to do next. He can never say that he has "completed" the work. He is challenged to do his best, and to accomplish as much as possible.

2. Informational Topics.

The study of related information is started as soon as the class understands the routine or procedure in the shop. This study is done by the group as a whole, under supervision, and
by individuals as they feel a need for study. Each topic is discussed by the class. Study periods are limited to about twenty-five minutes. This is usually closed with a five or ten minute discussion. Brief, concentrated study periods have been found most effective.

3. Testing.
Tests are given during the last week of the term. The first two of the series of performance tests are given on Monday and Tuesday, and the others on Thursday and Friday. The informational test is given on Wednesday.
The tests are scored according to the directions given in Appendices E and F. The scoring and rating of the test results take time but it may be done very rapidly by using special gauges for the performance tests and scoring keys for the informational tests.

4. Grading.
Final grading consists of combining the results obtained by each student in shop work, and in the tests. The scores earned for shop work are totaled, and distributed. This distribution should approach the normal curve. Grade-point values are assigned according to the distribution.
The tests are treated in the same manner. The grade-points are totaled and final grades are assigned on a basis of comparison. This involves some work on the part of the teacher, but it is pleasant, for the students know their grades are fair and represent actual accomplishment on their part.

Contract III presents a different problem for grading. The projects suggested for this contract do not have a "point" rating as in Contracts I and II. The range of difficulty and amount of work involved is much greater. Grades are assigned largely by subjective judgment. The author uses a forty-five minute period for a class exhibit. At this time each student places his work in a space provided for purpose. Each student is given a card on which he copies the names of the members of the class and grades the work of every other student. In addition the instructor grades the projects, considering factors such as: amount of work involved, difficulty of the work, general appearance of the finished project, application of the student, etc. The instructor's grade is then checked with the grades assigned by the student group. Reconsiderations and changes are made if the need is apparent.

B. Record of Application.

The following record of an application of the contracts to a class for one semester will enable the reader to bet-
ter understand their use. The class, whose record follows, started the semester with an enrollment of twenty-nine. Two of these transferred from the class the first week due to mistakes in registration. Three others dropped from the class by quitting school. At the end of the second contract another boy transferred by the request of his parents, so that he might have additional study periods. As the records show, he was progressing poorly. He would have earned credit, however, for he seemed to be a conscientious worker. A period of six weeks was spent on each contract. The class period was ninety minutes in length and assembled five times per week.

Students "S" and "V" presented interesting cases. "V" had great difficulty in doing the work. He spent practically twelve weeks working on the material for Contract I, although he was very conscientious and stayed on the job all of the time. He did a little welding, but was excused from the examinations for Contract II because he would have been unable to do them.

"S" was a different problem. He wanted something for nothing, but when he saw that he couldn't get it, he went to work and earned the grade he received. Office records showed this student to be a problem in all of his classes.
<table>
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<th>Group 3</th>
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* Project completed.
(*) Project not completed.

Note: Each project in Group 1 will count 10 points toward total score; in Group 2, 20 points; Group 3, 30 points.
### RECORD SHEET FOR PERFORMANCE TEST

**Part A—Contract I**

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**Note:** Underscoring on the "Distribution" column indicates the divisions in the distribution. Corrections are positive unless marked minus. Time corrections: See Appendix E.
-27-

RECORD SHEET FOR PERFORMANCE TEST

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Note: Underscoring on the "Distribution" column indicates the divisions in the distribution. Corrections are positive unless marked minus. Time corrections: See Appendix E.
**RECORD SHEET FOR PERFORMANCE TEST**

**Part C—Contract I**

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# Record Sheet for Performance Test

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*Note:* Underscoring on the "Distribution" column indicates the divisions in the distribution. Corrections are positive unless marked minus. Time corrections: See Appendix E.
COMBINED SCORES, GRADE POINTS, AND GRADES

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* Students actually received grades of "unsatisfactory 4".
### RECORD SHEET FOR SHOP WORK

#### Contract II

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* Project completed.  
(*) Project not completed.  
Note: Each project in Group 1 will count 10 points toward total score; in group 2, 20 points; in group 3, 30 points.
### RECORD SHEET FOR PERFORMANCE TEST

**Part A--Contract II**

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**Note:** Underscoring on the "Distribution" column indicates the division in the distribution. Corrections are positive unless marked minus. Time corrections: See Appendix E.
-33-

RECORD SHEET FOR PERFORMANCE TEST

Part B--Contract II

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Note: Underscoring on the "Distribution" column indicates the division in the distribution. Corrections are positive unless marked minus. Time corrections: See Appendix E.
# RECORD SHEET FOR PERFORMANCE TEST

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Note: Underscoring on the "Distribution" column indicates the division in the distribution. Corrections are positive unless marked minus. Time corrections: See Appendix E.
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**Note:**
- Underscoring on the "Distribution" column indicates the division in the distribution.
- Corrections are positive unless marked minus.
- Time corrections: See Appendix E.
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<td>N Ornamental iron birds</td>
<td>3</td>
</tr>
<tr>
<td>O Cold chisel, shop jobs</td>
<td>4</td>
</tr>
<tr>
<td>P Table lamp</td>
<td>4</td>
</tr>
<tr>
<td>Q Table lamp</td>
<td>3</td>
</tr>
<tr>
<td>S Shelf brackets</td>
<td>4</td>
</tr>
<tr>
<td>U Foot scraper</td>
<td>4</td>
</tr>
<tr>
<td>V Bridge lamp</td>
<td>2</td>
</tr>
<tr>
<td>W Bridle bit</td>
<td>3</td>
</tr>
<tr>
<td>X Smoking stand</td>
<td>3</td>
</tr>
<tr>
<td>Z Bridle bit</td>
<td>2</td>
</tr>
</tbody>
</table>
CONCLUSION

The author does not maintain that the program of instruction and the method explained in this study will overcome all the evils common to shop teaching, and will result in every student working to capacity. He does believe, however, that certain merits can be sighted.

A provision is made for the individual differences of students. Each contract is planned to cover certain operations common to forge work. The student is provided an opportunity to learn some of the related information, and to gain experience in doing the work. Three levels of experience are provided; one for the "superior", one for the "average", and one for the "slow". The informational topics are developed in class discussion. The superior students probably dominate in the class discussion, but the others may do their part in their own way. It is expected that the student will meet a challenge in each project. He knows what operations are involved. Can he learn and apply them? Can he make the project? Stress is placed on the mastery of the operations. They represent tools by which all projects are made. The work is presented in such a manner that he knows what the successful completion of a project will mean to him in building up a score for a grade. The spirit of competition is made prominent because the stu-
dent may compare their total scores as shown on a progress chart always available for reference.

The three levels of experience offered by the rated projects make it possible for the class as a whole to progress from one contract to the next on the basis of equal time intervals, except in extreme cases. This will undoubtedly result in a greater teaching efficiency, making possible a greater use of group instruction in larger classes.

Each student has an opportunity to choose projects which he can make. The teacher should guide the student in choosing those projects that will challenge his ability. An ideal opportunity for character building is offered in this plan, because every student may work on projects that he can do successfully, and yet, by proper choice be sufficiently difficult to challenge his ability. If one is to be successful in life he must be successful with his daily tasks. He must "taste" of success and not meet failure or "half success" at every turn.

Finally, each contract is completed with tests based on the operations and related information. These tests are designed to measure the manipulative ability of the students and their retention of related information. The student's progress in the shop and his retention of related information will probably be influenced by the test incentive.
The grades assigned to members of the class are determined largely by objective means. The student must do first-class work, instead of making a favorable impression, in order to receive a high grade. Grades are determined by objective measurement in so far as possible, instead of by subjective judgment.

The method presented here has met with favorable results under trial in actual shop conditions. The work done in the shop appears to be of a better quality than before it was adopted. Possibly the students worked more rapidly. Those students who continue with forge work seem much more able to work out their own problems. The method has been beneficial in one shop, though methods must fit the conditions existing in each particular case. They must fit the objectives of the course, and they must fit the instructor. In the final analysis "the instructor must work the plan", no matter what method or plan of instruction might be recommended or adopted.
BIBLIOGRAPHY
BIBLIOGRAPHY


Schwarzkopf, Ernst, Plain and Ornamental Forging, New York; J. Wiley and Sons, 1916.


APPENDICES
A COURSE OF STUDY IN ELEMENTARY FORGING

1. Introduction.

Iron is undoubtedly the most important metal used by man at the present time. Our present methods of earning a living, and our present methods of living are made possible due to the extensive use of iron and steel. The present age of luxuries is largely due to man's use of iron in producing what we call "the machine age". Regardless of the profession or position held by a person, he is continually coming in contact with or is using products or implements of iron or steel.

If the most important objective of industrial arts is general education, we should by all means give some form of iron work a place in the schools. Smithing or forging is one of the oldest of the crafts, and still maintains an important place in the industrial world. The nature of forge work has changed greatly. Some people think of it as a lost trade. It is true that horseshoeing and the work of the "village smith" have largely disappeared but forging processes are still basic to many forms of industry. Forging implies the shaping of metal by hand or machine, usually while it is hot. The following will give an idea of the uses of forging. Automobile
parts as fenders, crankshafts, and axles; tools of all kinds, and many machine parts are forged by machine in the factories. The extensive gas and water systems which are so common today have been made possible by the perfection of forging methods that produce pipe in large quantities. Forging has a more important place in industry now than it had before the time of the machine age.

The work in the school shop must be largely handwork, done on comparatively simple projects. However, these hand processes offer an opportunity for the student to gain considerable information concerning forging as it is practiced in industry, since the processes involved are fundamentally the same. The students' experiences in the shop will be enriched by motion pictures of factory work, visits to town shops, reading, and class discussion of related information.

The author has found that many students have developed an interest in the work to such an extent that they have constructed home-made forges, and carried on the work at home as a hobby. In this work they have built ornamental stands, curtain rods, brackets, door handles, toasting forks, etc. Many have used their home forges for reshaping and tempering tools such as cold chisels, punches, screwdrivers, picks, shovels, etc. Others have used their school experiences as an aid in securing summer
2. Objectives.

The following list of objectives are applicable to this and all other courses in forging. These objectives are specific and are attainable.

1. To acquaint the student with the importance of forging in industry and to show the relation which it has to other trades.

2. To acquaint the student with the important changes that have occurred, and the future possibilities of forging as a trade.

3. To acquaint the student with the many fields of related information, as mining, smelting, refining, marketing, designing.

4. To acquaint the student with the working conditions of the trade, in order that he may have a more sympathetic understanding of trade problems.

5. To acquaint the student with tools, materials, and operations common to the trade.

6. To develop a degree of skill in performing the fundamental operations of the trade, commensurate with the ability of the student.

7. To offer an opportunity to create or build with forged metal.

8. To create and stimulate an interest in forging as an avocation or hobby.
3. **Basis of Subject-Matter Selection.**

The choice of subject-matter in the following course is founded upon:

1. An analysis of the trade to determine what operations and technical material should be included.
2. A study of the related auxiliary information to determine that which would be suitable.
3. A study of projects to determine which ones could be used with the greatest teaching efficiency and yet take into account the individual differences of the students.
4. A psychological study of the interests, needs, and varying abilities of the students.

The course in elementary forging is designed primarily as a try-out course. This course should determine for the student whether his ability and interests warrant further work in this field.

4. **Outline of Selected Operations.**

   1. Building and maintaining a forge fire.
   2. Drawing.
   3. Cutting stock.
   4. Upsetting.
   5. Shouldering.
7. Heading and riveting.
8. Punching and splitting.
10. Chipping and filing.
11. Drilling.
12. Forge welding.
14. Threading.
15. Finishing of iron.
16. Operations of hardening and tempering of tool steel in so far as is necessary for the completion of the introductory projects which are offered.

5. **Informational Topics.**

1. Tools and equipment.
2. Care of tools and equipment.
3. Forge fires.
4. Forge fuels.
5. Working heats.
7. Safety precautions.
8. Types of hammer blows.
9. Structural changes due to forging.
10. Methods of fastening.
11. Classes of iron and their characteristics.
12. Historical uses of iron.
13. The puddling process.
14. The production of cast iron.
15. Types of forge welds.
17. History and development of the metal working industry. (Particularly as applied to forging.)
18. A study of the work of the Forgemaster.
APPENDIX B.

GENERAL INSTRUCTIONS TO STUDENTS,
CONCERNING ELEMENTARY FORGING CONTRACTS
APPENDIX B.
GENERAL INSTRUCTIONS TO STUDENTS,
CONCERNING ELEMENTARY FORGING CONTRACTS.

Introduction.

The work in Elementary Forging consists of completing three contracts. Certain directions for the work in this course are general and applicable to all of the contracts. Study the general directions carefully in order that you may profit, and progress most rapidly. This will be possible if the requirements of the various parts of the contracts are understood. The following is a general explanation of the work.

Shop Work.

Shop work is the principal part of each contract. The objective in doing the shop work should be to learn to perform the operations covered by each contract so that, when the course is finished, you will be properly prepared for more advanced work. This necessitates the development of some degree of skill in performing the operations, and the acquisition of some knowledge relative to the work. These objectives should influence the choice of projects, but the best work will be done if projects stimulating an interest are chosen. An opportunity is presented in the third contract for an application of skill in the making of projects such as table and floor
lamps, fire-side benches, smoking stands, and certain tools.

The shop work for the contracts consists of making one or more of the suggested projects or an original project that you may present. Original projects will be accepted instead of one of the suggested projects only if the new project involves the same or similar operations, and is not beyond the level of difficulty represented by the contract then in order.

The suggested projects are divided into three groups that represent three levels of difficulty. The first group presents few learning difficulties, does not require much skill, and does not involve much work. The second and third groups present more difficult problems corresponding to the score assigned to the projects in each group. Completion of the projects in the first group will earn ten points each; in the second, twenty points; and in the third, thirty points.

Blueprints for each group of projects are mounted on separate cards. An exhibited project of each one shown on the blueprints is mounted directly below the cards. A project plan or a set of working directions for each project in group one is given on the blueprints. Very brief directions are given for the projects in group two. It will be necessary to make more complete plans
if these projects are chosen. Practically no directions are given for making the projects in group three. It will be necessary to make complete plans if any of these are chosen. Preparation of complete plans is a part of the work involved in making these projects. You are expected to be able to develop plans if you can do work in this group.

Any project will be acceptable if it shows that you have done your best on it. However, it must meet the requirements of its intended use. Compare your project with the one exhibited when you think it is finished. Form the habit of doing your best on all projects.

Choose the project that you wish to make. It is advisable to choose one in group one first and then advance to the more difficult groups. Choose projects that you are sure you can make. After having successfully completed two of the suggested projects, you may make an original one. In this case the one presented must meet the requirements of the contract. The suggested project must involve the work covered by the contract. A working drawing of the project must be presented for the instructor's approval. Proceed as before if the project is acceptable. A score will be assigned that is agreeable to both you and the instructor.

Fill out a project card. After it has been checked
by the instructor, show it to the manager so that he may record your work on the progress chart. Get out the necessary stock. If the stock should be ruined, bring the record card to the instructor and he will mark it so that a new piece of stock may be secured.

As soon as a project has been finished, choose another, fill out a project card and continue as before. Make as many projects as possible. The student who earns the highest score will receive the most credit for shop work.

Project Cards.

Project cards are provided as a convenient form for keeping a record of all work done in the shop.

Study the card on the following page very carefully and fill out one for the chosen project in a like manner. "Date started" on the card means the date that the project is chosen. "Date finished", and the space after the word "Check" should be left blank for the instructor's use.

In the "Bill of Material" show the number of pieces of stock required, the size, the length, the kind of material, price per foot, but leave the cost column blank. When the project is completed, figure the cost and enter it in the column for that purpose. At the bottom of the column enter the total cost.

In the column headed "Old Operations" list those
Old Operations

Fire building and maintaining.
Drawing
Bending

New Operations

Upsetting
Punching

Project Plan.
1. Upset one end of the stock to about 2\" square.
2. Flatten this end on an aris to a little over \(\frac{3}{8}\) in thickness.
3. Off-set as required.
4. Punch and finish the eye.
5. Draw the point.
6. Take a short heat on the body and bend by using the tool hole and base of the horn.
7. Bend the point.
8. Straighten and finish.

Student
No. 341. Name: John Smith 34
Date Started: Feb. 8, 1933
Date Finished: Feb. 9, 1933
Course No.: 1
Project: Grab Hook
Group No.: 2
Project No.: 2
Points: 20

Bill of Material

<table>
<thead>
<tr>
<th>No.</th>
<th>Pieces</th>
<th>Size</th>
<th>Kind</th>
<th>Price</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>(\frac{5}{8})gr. 64&quot;L</td>
<td>M.S.</td>
<td>.04</td>
<td></td>
</tr>
</tbody>
</table>

Total: .04
operations on which you have already had experience, but which are also required for making this project. In the column headed "New Operations" list all operations that are new to you, and that are also required for making this project. These must be studied before making the project plans. Study the operation sheets for these new operations and then draw a line across the card as shown.

Make your project plans. These plans must be brief statements indicating step for step just what you intend to do. If the project requires the making of parts and assembling, develop the plans on these units. Later it may be found advisable to change the plans, but much more efficient work is possible if plans are carefully prepared for each project. Any task should be thoroughly planned before starting work.

Operation Sheets.

Instruction sheets known as operation sheets are provided to help you understand the operations and to assist you in learning how to perform and apply them. Some should be able to perform the operations after carefully studying the instructions. The demonstrations will supplement the operation sheets in these cases. The operation sheets are a permanent record of the demonstrations. By studying the sheets you will recall the demonstrations and be able to help yourself. Go to the instructor for
help only when you cannot solve your own problems. This will make it possible for your instructor to have more time for individual instruction at the forges with problems that cannot be solved by written instructions.

All work consists of applying fundamental operations to specific problems. If the operations of a certain trade are mastered they can be applied to any problem of that trade. By analyzing a project it will be found that it is necessary to perform certain operations in order to make it. You may learn much about doing the operations by studying the operation sheets.

The operation sheets for the first and second contracts are very brief. Their brevity means that every part of them is important. Before attempting a new operation, study the instructions for performing that operation. Write answers to the questions given at the end of the directions. Keep a notebook for this purpose. Have your instructor "O.K." each set of answers. All questions cannot be answered at this time. Look for the answers to these questions as the work of the contract progresses.

If difficulty is experienced in performing an operation, review the instructions for that operation. In most cases you will be able to help yourself. If not, consult the instructor. More detailed information may be secured by consulting the references given at the end.
of each set of instructions.

The instruction sheets for the third contract are informational. They present general plans for proceeding with the types of work for which they are prepared. These sheets should be thoroughly understood before attempting to make any of the projects in Contract III.

Informational Topics.

A study of certain informational topics is required as a part of each contract. The knowledge that may be gained from these studies will aid you in doing your work. Information of a general educational nature relative to the metal working trades may also be acquired. Informational Topic Guide-Sheets are provided to assist in this part of the work.

Occasionally during the term the class will remain in the class room to study and discuss problems relative to forge work. The Informational Topic Guide-Sheets will be found valuable as a bibliography of reference materials. In most cases definite page references are given for each topic. Study these so that you may contribute your part to the class discussion. Some topics do not have references given. In these cases the instructor will furnish the necessary information. Notebooks should always be available for recording the information secured in class discussion.

Form the habit of making every minute in the class
count. If a project is completed and there is not sufficient time to start another on that day, the remaining time should be spent in studying. Everyone can find something worthwhile to do if he tries. If you wish to enjoy the forge work, keep busy. This plan also helps you to accumulate more grade-points, and consequently a higher grade.

**Progress Chart.**

The progress chart is a collective record of the work done by the class. This record is posted in the shop so that each person may see how well he is progressing in relation to the rest of the class.

The progress chart is filled out by the manager. After a record card has been checked by the instructor, the manager marks the chart so as to indicate what project is being made. When the project is accepted the card is initialed by the instructor and the manager marks the total score on the chart. By comparing the scores of the members of the class you may know how well you are progressing in relation to the rest of the class.

**Informational Test Material.**

A statement of the points used in the informational tests is given as an aid for reviewing the work. These sheets of information will be posted during the fourth week of the term. You should read them through at least
once, and then study the parts with which you are not familiar.

Tests.

Tests are given to assist in determining grades and to call attention to important parts of the work. A test will be used that will indicate your ability to do the work. This test is known as a performance test. Another test will be used to determine your retention of related information, and knowledge of fundamental processes. Specific directions will be furnished with each test. The points earned in these tests will help to increase your total score.
APPENDIX C.

CONTRACT I, WITH OPERATION AND INFORMATION SHEETS
APPENDIX C.

CONTRACT I, WITH OPERATION AND INFORMATION SHEETS.

Introduction.

Contract I is designed to give an introduction to forge work. The projects that may be made are very elementary. However, they will challenge your ability. The forging operations included in this contract are basic to the trade. Your objectives in this contract should be to develop as much skill in applying the operations, and to acquire as much information relative to the work as possible. Otherwise successful work in the following contracts is impossible. This may be accomplished by making the suggested projects and studying the related informational topics.

Contract I offers an opportunity to make projects that will give experience in performing the following operations.

1. Building and maintaining a forge fire.

2. Drawing. This consists of making the stock smaller and longer by hammering or pressure.


4. Cutting stock. This involves cutting stock with the cold shear, hack-saw, cold and hot hardy, and the cold and hot chisels or cutters.

5. Punching and splitting. This consists of making a hole in a piece of stock by driving a punch through the stock, or splitting the stock as for making a fork.
6. Heading and riveting. Heading implies the forging of a head as for a nail, bolt, or rivet. Riveting implies joining two or more pieces of stock by the use of rivets. Either case involves the forming of heads.

7. Upsetting. This involves making stock larger by hammering or pressing on the ends of the stock. Any part or the whole of the stock may be upset.

8. Shouldering. This consists of making the stock smaller at a certain designated spot, as for making a tenon.

Study the operation sheets for further information. The informational topics for this contract are listed on the guide sheets.

The contract is completed with a series of tests.
SUGGESTED PROJECTS

FOR CONTRACT I
CONTRACT I.  Project I.  Punch  Group I.

Stock $\frac{1}{2}$ R - 6" L

Directions:
1. Square up one end.
2. Lay out 2" from the square end and draw the remaining stock to $\frac{3}{8}$ square.
3. Lay out 4" from square end and draw the remaining stock to $\frac{3}{8}$ octagonal.
4. Draw the point as required.

Ensign Johnson,
Oct. 21-32. R.U.H.S.
CONTRACT-I  
Project-2  
Punched Ring  
Stock \( \frac{3}{8}'' \times \frac{1}{2}'' \times 3'' \)
Scale 12'' = 1'

Directions
1. Lay out the stock.
2. Split.
3. Spread and shape on the horn.
4. Draw to required size.

Diagram:

\[
\text{Diagram of a punched ring with dimensions:}
\text{Outer diameter: } 1\frac{5}{8}''
\text{Inner diameter: } 5\frac{5}{16}''
\]

Drawn by Thomas Brown 2133
PUHS. Oct. 20, 1932
CONTRACT-I

Proj.c73

Use stock from scrap box

Scale - 12" = 1'

Wedges

A

B

Directions

1. Draw stock to required dimensions.
2. Cut about one-third of the way through on each side and break off.

Staples

Stock - \( \frac{1}{4} \) R. \( \times \) 3\( \frac{3}{4} \) L.

Directions

1. Draw square points \( \frac{1}{2} \)" long on each end.
2. Bend to required shape.

R.U.H.S. Thomas Brown 2133 Oct 27-32
CONTRACT I  
Project 4  
Group I

Nail
Stock—from scrap box

Scale 12"=1

Directions—
1. Shoulder and form the body of the nail.
2. Cut and form the head.

Note—
Dimensions for head do not need be exact.

Drawn By Ensign Johnson
P.U.H.S. Oct. 26-32

Rivet
Stock—from scrap box

Directions—
1. Upset and form the head.
2. Cut to length.

Note—
Dimensions for the head must be exact.
**CONTRACT-I**

**Project-I**
Scale - 12" = 1''

**S-Hook**
Stock 1/4"R. x 8 1/4"L.

**Eye Pin**
Stock 1/4"R. x ?L.

**Directions**
1. Draw points on each end 1/2" long.
2. Bend to required size.

(Thomas Brown) (PUHS.)

**Group - 2**

**Directions**
1. Calculate length of stock needed
2. Bend the eye according to the directions on operation sheet.
CONTRACT 1  Project 2  Group 2

Grab Hook
Scale Full Size
Stock 5/8 sq. 6 1/4 L

Directions:
1. Upset and form the eye.
2. Draw the point.
3. Bend the hook.

Drawn By Bob Benckendorf
October 27 PU.H.S.
CONTRACT - No.1

Project - 3

Group No. 2

FORGE RAKE

Stock 3/8 Rd. 32 L

Scale 6" = 1"

24"

Drawn By Ensign Johnson

Hammock Hook
Scale 12"=1'
Stock 3/8 R. 8 1/2"

Directions:
1. Bend the eye.
2. Draw a blunt point about 1/2 long.
3. Bend the hook. 3/8

Drawn by Ensign Johnson.
Nov. 3-32. P.U.H.S.
CONTRACT I

Project I

Swivel Eye

Group 3

Stock \( \frac{3}{8}'' \times 1'' \times 5'' \)

Scale Full Size

Drawn By Bob Benckendorf P.U.H.S.
CONTRACT I  Project 2  Group 3

Pipe Hook
Scale 1/2 Size
Stock 1/2 sq. 9'L.

Directions:

1. Upset stock in the center to 1/2 x 7/8.
2. Shoulder and draw the part for the hook.
3. Bend the hook.
4. Draw the point.

Drawn By Bob Benckendorf 4063  P.U.H.S.
Hay Hook
Stock $\frac{1}{2}$R. x 19"L.
Use 11" of stock for the handle
Scale 6" = 1'

Per 5-6 PUHS, Thomas Brown Nov. 8-32
CONTRACT I
Project 4
Clevis and Pin

Group 3

Scale 1" = 1"

Head 3/8 Thick

6"

3/4" Rd.

2 1/8"

3/16"

1/2" Rd.

6 1/4"

1/4"

0.5"

Drawn By Von Brenkendorf
3-13-33 PUHS
OPERATION SHEETS

FOR CONTRACT I
Introduction.

This operation cannot be given too much careful consideration. A great part of the successful completion of a project is directly dependent upon properly heating the stock in a correctly built and maintained forge fire.

Directions.

1. Clean the fire pot of dirt and clinkers.
2. Light a handful of shavings over the tuyere, and turn the blower slowly.
3. Lightly cover the kindled fire with small pieces of coke.
4. As the coke catches fire rake in the remaining coke on the pan.
5. Sprinkle water around the edges, and if necessary bank the sides and back of the fire with green coal.
6. Keep the sides of the fire pushed in so that a hole does not form in the center. The center of the fire should be the highest part.
   (Note.) Satisfactory work is impossible with a poor fire.

Questions.

1. Why should only a small draft be used when starting a fire?
2. What is green coal?
3. What is the effect of letting a fire get hollow? an oxidizing fire? a reducing fire?
4. Why should the size of the fire correspond to the size of the project?
5. Why should molten cinders be cleaned out of the fire?
6. Why use a high grade of bituminous coal instead of other fuels?

7. What safety precautions should be observed?

References:


2. Ilgen, W. L., "Forge Work", pp. 1; 4; 48.

DRAWING OUT STOCK

Introduction.

Drawing out, or drawing, means decreasing the cross-sectional area of the stock by hammering or pressure. This involves straight drawing, chamfering, beveling, and pointing, on square, round, flat, octagonal or hexagonal stock. It is one of the most commonly used operations. Much practice is required for developing skill in hand drawing.

Directions.

1. Heat the stock to a forging heat (yellow), and place it on the anvil. Short stock should be held in suitable tongs.

2. Straight drawing. Strike so that the face of the hammer is parallel to the face of the anvil. (Use an upright hammer blow.)

   a. To draw square stock. Turn the stock in one direction and then the other, so as to strike approximately an equal number of blows on all sides of the stock.

   b. To draw round stock to a square. Strike a blow and rotate the stock one-quarter turn. Strike again, roughly forming a square shape. Rotate the stock and continue striking as for drawing square stock.

   c. To draw square stock to a round. If necessary, draw the stock to a square size that is the same as the size of the finished product, i.e., for a finished one-half inch round, the stock should be drawn to one-half inch square before starting to make it round.

   Hold the stock on an arris. Strike an upright blow. Rotate the stock one-quarter turn and strike again, roughly forming an octagon. Figure 1.

   Continue the operation until the stock is octagonal. Smooth out the arrises of the octagonal stock with carefully directed blows until the stock is round.
d. To draw round stock to a smaller round.
   Draw the round stock to a square. (See "b" above.) Reduce the square stock until it is the necessary size. (See "c" above.) Draw the square stock to a round as before.

3. To draw points, chamfers, bevels, etc. Strike so that the angle formed by the face of the anvil and the face of the hammer will be approximately the required angle of the point. (Use the angle blow.)

Place the end or point of the heated stock even with the far edge of the anvil. Figure 2.

Strike angle blows and rotate the stock as for straight drawing. If the end tends to become concave, hammer straight back on it to keep it square or slightly convex. The point will crack if the stock is left concave on the end.

When drawing a round point, be sure to forge a square one first and then make it round as in straight drawing.

(Note.) It is a good plan to draw a short point and then increase it to the required length. Use light hammer blows when forging the tip of
the point.

4. Finish all forgings by hammering lightly when the stock is at a dull red heat.

5. If tongs are used, be sure that they hold the work firmly.

6. Stock may be drawn by holding it across the horn of the anvil and hammering on top of the stock. The length will be increased without increasing the width.

7. The peen of a cross or a straight peen hammer may be used for drawing. Strike with the peen at right angles to the work to increase the length. Stock may be spread without increasing the length by striking with the peen parallel to the length of the stock. This type of drawing should be done on the base of the horn.

8. The fullers are often used for drawing heavy stock. When the fullers are used the stock is usually finished with a flatter. This type of work requires a helper who strikes the tools with a sledge.

Questions.

1. Why rotate the stock one-quarter turn between blows? Must this rule always be followed?

2. What may cause points to crack or split?

3. Why hold the end of stock even with the edge of the anvil when drawing it down thin or small as for a point?

4. Why should tongs be fitted to the work?

5. Why should tongs be cooled frequently?

6. What is the affect of over-heating iron?

7. What is the purpose of the groove in the jaws of flat jawed tongs?

8. What causes iron to scale and blister?

9. What causes diamond-shaped pieces? How can they be corrected?
10. What safety precautions should be considered when drawing out iron?

References.

1. Schwarzkopf, Ernest, "Plain and Ornamental Forging", pp. 17-18; 20-21; 33; 35; 37; 52; 56.


Introduction.

Bending involves the shaping of bars of iron so as to conform to certain required regular or irregular curves. Bending may be done by hammering the stock while it is held over the horn or the edge of the anvil. When a great number of the same bends are to be made they are often bent on a form.

Directions.

1. Heat the stock to the necessary temperature for easy bending; small stock may be bent while at a red heat. Heavier stock should be heated to a forging (yellow) heat. The stock must be uniformly heated for an even bend.

2. Strike so that the face of the hammer comes in contact with the metal beyond the horn or edge of the anvil. (Leverage blow).

3. Bending a ring over the horn. Place the end of the heated stock just over the horn and start the bending. Extend the stock a little farther and continue the bending until about one-third of the stock has been properly shaped. Figure 1.
Hold the stock in hollow bit tongs and repeat the same process on the other end.

Hold the stock upright on the face of the anvil with a pair of link tongs and hammer the stock so as to close the ring. Figure 2.

Straighten and smooth the ends of the stock so that they will fit closely. A file may be used. If the ends of the stock are beveled very slightly before bending it should not be necessary to file the ends after bending.

4. Making an eye-bend. Estimate the stock necessary for making the eye. (See information sheets.)

Lay out the length and mark it with a center punch.

Heat the stock at the punch mark to a forging heat, and bend it to form a right angle. Figure 3.

- Figure 3 -
The dotted lines and letters indicate the steps.

- Figure 4 -
The arrows indicate the direction for hammer blows.

Begin the bending of the stock as in "3" above. Bend the stock as far as possible on the horn and close the eye on the edge of the anvil. "A", "B", "C", and "D", of Figure 3 indicate the proper procedure.
5. Bending may be done over the edge of the anvil as for a scroll. You must determine how and where to strike by watching your work. Figure 4.

6. Bending may be done by using the stock as a lever in the hardie hole, or the pritchel hole of the anvil.

7. When many duplicate bends are to be made a special form should be used to save time.

Questions.

1. Why is it necessary to have a uniform heat for bending?

2. What would be the advantage of striking a glancing blow on round stock while bending?

3. Why not deliver blows directly over the point of contact on the horn?

4. When making an eye-bend, why is it advisable to first bend the stock at right angles?

5. Why is the dimension at the center of the stock used for determining the length needed for a curve, or bend?

6. If a piece of work is bending unevenly, how can it be corrected?

7. What safety precautions should be observed?

References.

1. Schwarzlopf, Ernest, "Plain and Ornamental Forging", pp. 38; 42; 55; 60.

2. Ilgen, W. L., "Forge Work", p. 34.

Introduction.

Cutting involves getting out stock with the cold shear or hack-saw; cutting it at the anvil with a hot or cold hardie, or hot or cold cutter, or chisel. It also involves cutting off surplus stock at the anvil in the making of a project. Always be economical when getting out stock. Make accurate measurements and cut so as not to waste the stock.

Directions.

1. Cutting stock on a hardie. Mark the stock with a chisel or punch before heating.

   Stock may be cut cold by using a cold hardie, but usually it is heated to a forging heat and cut on a hardie designed for cutting hot stock. This hardie is called a "hot hardie".

   Place the mark on the edge of the hardie and cut in about one-third of the way from all sides of the stock. Heavier stock will require a deeper cut, but this will be learned from experience.

   Place the stock over the edge of the anvil and break it in two by bending the end back and forth.

   Only experienced smiths should attempt to cut stock entirely off on a hardie.

2. Cutting stock on a cold shear. Use the cold shear for cutting any stock one-half inch square or smaller, if it has not been heated or forged, and providing it is mild steel, or wrought iron. Never attempt to cut tool steel with the cold shear. The size of stock which may be cut on a cold shear is determined by the size of the shear.

   Lay-out and mark the length of stock required with chalk, or soap stone.

   Place the stock in the shear and cut it by operation of the lever.

3. Much cutting on heavy stock is done with tools called cutters or chisels. They are held by a
handle with the cutting edge on the mark and a helper strikes the head of the tool with a sledge.

4. Cutting stock with a hacksaw. This involves cutting the stock with a metal cutting saw. The blades are very hard so must be used with care.

Questions.

1. Why should stock never be cut entirely in two on a hardie by an inexperienced workman?

2. Why is a cold hardie tempered, and a hot hardie not tempered?

3. Why are hot and cold hardies, and cutters, shaped differently?

4. What precautions should be observed when cutting short stock with a cold shear?

5. What are the advantages of an orderly supply rack?

6. Why should a cold shear not be used for cutting stock which has been forged?

7. How should a hardie be sharpened?

8. Why should a new saw blade not be used in an old kerf?

9. What safety precautions should be observed when cutting stock?

References.

1. Schwarzkopf, Ernest, "Plain and OrnamentalForging", pp. 28-29; 34; 44.


PUNCHING AND SPLITTING

Introduction.

Punching consists of making a hole in a piece of stock by driving a tool called a "punch" through the stock. Splitting is done very much the same as punching except that a cutting tool or very thin flat punch is used. Splitting may be done in the center of a piece of stock to form an eye or a slot, or at the end to form a fork.

Directions.

1. Lay out and mark the center of the hole with a center punch.

2. Heat the stock to a forging heat.

3. Place the stock so that the punch mark will be about over the center of the face of the anvil. When punching a hole next to a shoulder it may be necessary to punch the hole from one side of the stock at the edge of the anvil. The stock should be punched from this side first. Figure 1.

Center the punch on the mark, and drive it about two-thirds of the way through the stock. Figure 2. Remove the punch frequently to cool the end.
Turn the stock over so that the little bump or dark spot will be over the tool or pritchel hole.

4. Drive the punch through to open the hole.

5. Drive the punch in from alternate sides until the hole is the required size.

6. Holes which must have true sides, or special shapes should be finished by driving a special punch called a "drift" through the hole.

(Note) The drift is made the size of the finished hole. A drift must not be used for punching the hole in the stock—just for finishing the hole to the required size and shape.

7. Large punched holes are formed by punching or drilling two small holes, and then splitting the stock between the holes. A thin flat punch may also be used. Finish the hole by spreading it on punches until it may be drawn larger on the horn of the anvil or a special form. Figure 3.

8. Splitting is done usually with a hot cutter. The stock may be split through by holding the stock on the base of the horn, or by shearing it at the edge of the anvil. The stock should be split equally from each side.
Questions.

1. Why should the first blow on the punch be a hard one?

2. Why should the point of the punch not be allowed to remain in the metal very long?

3. How may the point or end of the punch be prevented from becoming upset and stuck in the stock?

4. What suggestions may be given for removing a punch that is stuck?

5. What safety precautions should be observed?

References.


HEADING AND RIVETING

Introduction.

Heading consists of forming heads as on a bolt, nail, or rivet. Riveting is practically the same as heading except that it implies the fastening of two or more pieces of stock together.

Directions.

1. Forming a head by upsetting the stock. Upset the stock the required amount for the head. (See operation of upsetting.)

Place the stock in the proper size heading tool, i.e., use a 1/2" heading tool for heading a 1/2" bolt. Figure 1.

Flatten the head with upright blows until the thickness of the head is about one and one-half times that of the finished head. Check the location of the head in respect to the body. If necessary drive the head over the center of the body by drawing it to the desired position as the heading operation is continued. Figure 2.

Figure 1

The body of the bolt extends into the tool hole.

Figure 2

When the head is centered and the proper size, forge the required shape.
2. Forming a head by drawing out the stock to form the body.

Select stock one-eighth to one-fourth inch larger than the body of the finished piece, i.e., for a nail having a body of 1/4" in diameter use 3/8" or 1/2" stock.

Estimate the amount of stock needed for the head and the body. Make an allowance for waste. See "Informational Topic Guide-Sheet" for reference.

(Note.) When making small jobs it is best to use a convenient length of stock, cutting off the actual amount used after the body has been drawn.

Mark the location of the shoulder with a center punch.

Shoulder the stock and draw out the body. (See Shouldering and Drawing.)

Form the head as in "1" above.

3. Cupping tools are sometimes used for finishing the head.

Questions.

1. Why should the head of the stock not be flattened to the required thickness when it is first placed in the heading tool?

2. Why should a high heat be used when upsetting the head in the heading tool?

3. Why should the heading tool be slightly larger than the body of the project?

4. Why is the hole in a heading tool tapered? Which side should be placed up when being used for heading?

5. What are the differences between heading and riveting?

6. How may stock be removed from a heading tool if the stock should stick?

7. What safety precautions should be observed?
References.

1. Schwarzkopf, Ernest, "Plain and Ornamental Forging", pp. 43; 62; 68; 77.

UPSETTING

Introduction.

Upsetting consists of increasing the cross-sectional area of the stock by hammering or pressure on the ends of the stock. The fibers or grain of the stock are made to slip by each other in this operation so a high heat is necessary.

Directions.

1. Heat that part of the stock which is to be upset to a light yellow heat—almost white.

2. Hold the stock in the most convenient manner. The stock may be held in tongs across the face of the anvil so that the hot end may be struck with the hammer. The stock may be held on top or against the side of the anvil. When using this method the hot end should be placed against the anvil. Another method of holding short stock is shown by Figure 1. Figure 2 shows how to hold stock on the top of the anvil.

3. The blows on the end of the stock must be hard.
Hard blows must be used to prevent just riveting the end which is being hammered. The force of the blow must extend through the section to be upset.

4. Control the upsetting to the proper place on the stock by cooling it where it is not to be upset.

5. When the stock bends, straighten it immediately. The stock must be kept straight and symmetrical.

(Note) The experienced smith acquire sufficient skill to estimate the amount of stock required for an upset section. However, the beginner must resort to arithmetic, and calculate the amount of stock needed. Then add to this enough to allow for waste due to scaling. This calculation is done by figuring the volume of the stock needed for the upset section. Then find how long a piece of stock will be needed for this volume.

Questions.

1. Why is such a high heat necessary when upsetting?

2. Why should the heated end of the stock usually be placed on the anvil?

3. Why are hard blows necessary?

4. Why must the stock be kept straight and symmetrical?

5. What are some uses for upsetting?

6. What safety precautions should be observed?

References.

1. Schwarzkopf, Ernest, "Plain and Ornamental Forging", pp. 77; 62; 101; 117.


Shouldering consists of decreasing the cross-sectional area of the stock at a given point. Stock may be shouldered on one, two, three, or as many sides as the stock has. It is used for forming tenons, etc.

Directions.

1. Calculate the amount of stock needed for the project.

2. Lay-out and mark the stock.

3. Shouldering on one side of the stock. Place the stock on the face of the anvil with the punch mark even with the edge of the anvil.

Strike with over-hanging blows until the shoulder is formed to the required depth. Figure 1.

(Note.) The edge of the anvil forms the shoulder. Over-hanging blow—the face of the hammer extends over the edge of the anvil.

Figure 1
Face of the hammer extends over the face of the anvil (Over-hanging)

Figure 2
Side of hammer even with side of anvil (Edge-to-edge)
4. Shouldering on two sides of the stock. Place the stock on the anvil the same as for shoulder- 
ing on one side of the stock.

Strike with edge-to-edge blows forming the 
shoulder on one side with the hammer, and on the other with the edge of the anvil. Turn the 
stock occasionally so that the anvil aids in forming the shoulder on each side. Figure 2.

5. Large stock is usually shouldered by fullering and drawing. The fullers are often used for rough drawing of the stock and the flatter or swage for finishing. The set hammer is used for forming a sharp shoulder. These tools are struck by a helper with a sledge. Figure 3.

Shoulders may be squared up by driving them into a heading tool, a die, holes in the swage block, or into the jaws of a blacksmith vice.

References.

1. Schwarzkopf, Ernest, "Plain and Ornamental Forging", pp. 53; 56; 115; 117.

INFORMATIONAL TOPIC GUIDE-SHEET.

Contract I.

While completing the shop work for Contract I, each student is expected to familiarize himself with the topics listed below. He should be able to identify and give the uses of the important equipment such as the forge, anvil, etc. He should be able to name and give the uses of all the tools. He should have an understanding of the related information.

The references suggested for study are as follows:

A. Schwarzkopf, Ernst, "Plain and Ornamental Forging".

B. Selvidge, R. W., and Allton, J. M., "Blacksmithing".

C. Ilgen, W. L., "Forge Work".

D. Littlefield, J. D., "Notes for Forge Shop Practice".

E. Richards, W. A., "Forging of Iron and Steel".

The letters "A", "B", "C", etc., given after each topic indicate respectively the references that may be used for sources of information.

A. Tools and equipment.


5. Sledge. (A) p. 21. (B) p. 130. (C) p. 9.

6. Tongs. (A) p. 21. (B) p. 130. (C) p. 9.

7. Cutting tools. (A) pp. 28-30. (B) p. 133. (C) pp. 12-14; 27.


13. Set hammer. (A) p. 24. (B) p. 131. (C) p. 15. (E) p. 46.


15. Vises. (A) p. 31. (C) p. 22. (E) p. 42.

B. Related information.

1. Forge fires. (A) p. 16. (B) p. 128. (C) p. 48. (D) p. 10. (E) p. 51.

2. Fuels. (A) p. 15. (B) p. 129. (C) p. 5.


5. Principal classes of iron and their characteristics. (A) p. 3. (B) p. 136. (D) p. 7.


7. Source of iron. (A) p. 2. (C) pp. 161-162.

8. Stock calculation.
   a. For bends. (A) pp. 39; 40; 56.
   b. For drawing, upsetting, shouldering, and punching.

9. Why iron will cut iron.

10. Care and repair of tools and equipment.
11. Hammer blows. (A) pp. 52-56. (C) pp. 30-36.
12. Structural changes in iron due to forging.
INFORMATIONAL TEST MATERIAL.

Contract I

The following sheets of information are statements of points used in preparing the informational tests. These sheets should be used only for reviewing purposes.

A. The forge fire.

1. Clinkers are formed by a fusion of the iron scales and dirt from the coal.

2. Clinkers will cover the bottom of the fire pot and cut off the draft. They may ruin the lining of the forge.

3. The top of a fire should never be covered with green coal except to form a special type of fire.

4. Green coal should not be banked across the front of the fire.

5. Push in the sides to prevent a hole forming in the center of the fire.

6. A fire should be banked with green coal, or coke, to maintain a supply of coke and to confine the heat to the center of the fire.

7. A fire should be deep enough to have four or five inches of fire under the iron and one or two inches of fire over the top of the iron.

8. A hollow fire will oxidize the work while it is being heated.

9. An oxidizing fire is one which has a hole in the center, or is shallow. The oxygen in the air is not consumed before it reaches the iron.

10. A reducing fire, deep, will destroy the oxidized surface on the iron. The oxygen is completely used by the fire, and the surplus carbon will consume the oxygen in the iron scales.

B. Forge fuel.

1. Coke is formed in the forge fire from green
coal around the fire by burning out the gas and oil, or volatile material. The heat of the fire produces this change.

2. Green coal is formed by dampening soft or bituminous coal with water.

3. Only a high grade of bituminous coal should be used for blacksmithing fires.

4. Charcoal is especially good for heating tool steel because it is free from impurities, but is too expensive for general work.

5. Hard coal is not satisfactory for forge work because it burns to ashes without forming coke.

C. Heating iron.

1. Hot pieces of iron should never come in contact with fresh or green coal.

2. Stock should be placed in the fire in a horizontal position for heating.

3. A dark red heat is used for finishing a forging.

4. A yellow heat is used for forging.

5. A bright red heat should be avoided as much as possible because the iron scales very badly when in the air at this heat.

6. Iron expands when heated.

7. Wrought iron and steel become soft and pliable when heated.

D. Hammer blows and their functions.

1. The upright blow is used for straight drawing.

2. The angle blow is used for drawing points, bevels, chamfers, etc.

3. The leverage blow is used for bending.

4. The edge-to-edge blow is used for forming shoulders on opposite sides of stock at the same time.

5. The over-hanging blow is used for forming a shoul-
der on one side of the stock.

E. Forging tools and equipment.

1. Fire tools.

The rake is used for raking coal onto the fire, cleaning the fire, and pushing in the sides of the fire.

The poker is used for loosening the fire so that the draft may come through more freely.

The shovel is used for placing coal onto the fire and in preparing green coal.

The sprinkler is used for dampening the sides of the fire.

2. The forge.

The fire pot aids in holding the fire in the proper shape.

The pan holds surplus coal and coke which may be on the top of the forge.

The hood collects the smoke from the fire.

The tuyere allows the draft to enter the fire and holds the fire so that it cannot fall down into the bottom of the forge. The tuyere permits the fire to be cleaned without being destroyed.

The blower furnishes the draft for the fire.

3. Hand hammers.

Cross peen—the eye is at right angles to the peen.

Straight peen—the eye is parallel to the peen.

Ball peen—the peen resembles a section of a ball.

For most purposes the hammer handle is grasped about two-thirds of the length from the hammer head. A sense of balance should be felt by the operator. For finishing, the handle should be held closer to the head.
4. Tongs.

Flat jawed, hollow bit, and link are the most common tongs.

Tongs should not be allowed to become heated while they are being used for holding stock.

If tongs become heated, as for reshaping, they should be cooled slowly.

Tongs should not be used if they do not fit the stock correctly.

5. The anvil.

The horn is used for bending, and some drawing.

The base of the horn is used to support stock when it is being cut with a cold or hot chisel.

The face of the anvil is used for drawing, straightening, etc.

The tool hole is used for holding tools such as the hardie, bottom fuller, bottom swage, etc. It may also be used when punching or bending.

The pritchel hole may be used when punching or bending.

The heel is used for drawing and straightening on special jobs.

The round, and square, edges are used for forming square or rounded shoulders.

The body gives weight and strength to the anvil.

6. The cold shear should never be used for cutting hot iron, iron which has been forged, or tool steel.

7. The hook scale is used for measuring.

8. Hammers, punches, and chisels are made of a high grade of tool steel.

9. Drift punches should not be used for making a hole.
10. Drift punches are used for finishing a hole to the required shape and size.

11. The heading tool is used for holding stock while forming heads. The hole in a heading tool should be tapered and slightly larger than the body of the job.

12. The fullers are chiefly used for shouldering and drawing.

13. The set hammer is chiefly used for forming sharp shoulders, and drawing in narrow spaces.

14. When using special tools such as fullers, swages, punches, etc., a smith should have a helper who strikes these tools with a sledge.

15. The swages are used for finishing round stock, and for special forming. They should not be used for drawing.

16. The flatter is used for smoothing and straightening flat surfaces. The flatter should not be used for drawing.

17. The sledge is a heavy hammer used by a helper.

F. Operations.

1. Drawing consists of reducing the cross-sectional area of the stock.

All drawing should be done when the section of the stock is either square or rectangular.

To draw a round piece of stock to a smaller round, draw the stock to a square and then draw it to a square size which is the same as the required size of the round. Draw this square to an octagonal shape, and then make it round.

Points and thin edges should be drawn on the far edge of the anvil so that the hammer will not become chipped, nor the face of the anvil roughened. The hammer should never be struck against the face of the anvil.

The following are causes for splitting of points.

1. Hitting too hard on a small point.
2. The stock has been over-heated.
3. The end of the stock was concaved.
4. The stock has a flaw, or slag seam in it.
5. Failure to keep all sides drawn equally while forming the point.

When drawing, the stock should be rotated to keep all sides drawn equally and prevent twisting the stock.

2. Punching.

Punching consists of making a hole in a piece of stock by driving a tool called a punch through the stock.

Stock which is to be cut, split, shouldered, punched, etc., while hot should be marked with a center punch.

The first blow on a punch should be fairly heavy so that the punch will be started into the metal without bouncing out of position.

The end of a punch should not be allowed to remain in the stock until the punch becomes heated, because it will expand and become stuck or may become upset due to hammering.

A punch should be removed from the stock and cooled frequently. Placing a lump of coke in the hole will tend to prevent sticking of the punch.

3. Splitting is very similar to punching except that a cutting tool or a very thin flat punch is used.

4. Bending.

When making eyes, and rings, the bending should always be started at the extreme ends of the stock.

A uniform heat is necessary for making an even bend.

Stock cannot be bent correctly unless it is heated correctly.

5. Heading consists of forming heads on stock as for bolts, rivets, and nails.

When forming a head, the stock for the head should not be flattened to the required thickness until
after the head is properly located in respect to the body. The head must be centered on the body first.

A heading tool should be used with the small side of the hole on top.

6. Upsetting consists of increasing the cross-sectional area of the stock.

When upsetting, the fibers, or grain, of the stock are made to slip by each other and tend to become farther apart. A light yellow heat, almost white, should be used for this operation.

When upsetting stock, it is necessary to strike hard blows because the light ones tend to just upset or rivet the end of the stock.

7. Shouldering consists of decreasing the cross-sectional area of the stock at a given point.

Shoulders may be formed on adjacent sides of stock by using the over-hanging blow on adjacent sides of the stock.

Shoulders are formed on opposite sides of the stock simultaneously by the use of the edge-to-edge blow.

G. Methods of fastening.

The following devices are commonly used. Welding and similar methods are not considered here.

- Bolts
- Rivets
- Clamps
- Set screws
- Shrink fit
- Drive screws
- Cap screws

H. Iron.

1. The three principal classes of iron are: cast or pig iron, steel, and wrought iron.

2. Wrought iron and steel are both used in forging.

3. Iron has been used by man for about 5,000 years.

4. Iron used commercially is never pure. It always contains some carbon.
5. Iron is obtained from the earth as a mineral in the form of ore.

I. A right-handed person should work at the anvil so that the horn of the anvil is at his left.

J. Stock calculation.

1. Requiring volume calculation.

Calculations for drawing, upsetting, heading, shouldering, punching, and splitting must be made on the volume of the stock.

2. Requiring figuring from the center-line of the stock.

Calculations must be made on the center-line of the stock for all bends. For irregular curves or bends the center-line is actually measured with dividers, wire, or a measuring wheel.
APPENDIX D.

CONTRACT II, WITH OPERATION AND INFORMATION SHEETS
APPENDIX D.

CONTRACT II, WITH OPERATION AND INFORMATION SHEETS

Introduction.

Contract II is designed to give additional experience in forging. The suggested projects for this contract are more complicated and require the performing of several new operations. As in Contract I, your objectives should be the development of skill and the acquisition of information concerning forging and the related topics. Accomplish this by making projects in which you have an interest. The procedure for Contract II is the same as for Contract I.

Contract II introduces the following new operations.

1. Twisting.

2. Chipping and filing. This involves the cutting and smoothing of stock with the cold chisel and file.

3. Drilling. This involves the making of a hole with a tool called a drill. The drill is usually operated by a machine.

4. Welding. This consists of making a cohesive union between two or more pieces of like metal.

5. Grinding. This involves the use of an emery grinder.

6. Threading. This involves the operation of hand threading tools.

7. Finishing. This involves the preparation of the surfaces of projects for the purposes of preservation and appearance.
SUGGESTED PROJECTS

FOR CONTRACT II
Directions.
1. Get stock.
2. Build a good clean fire.
3. Bend the stock as directed for ring.
4. Test the fire for welding.
5. Make practice ring of scrap stock.
6. Scarf and weld the ring.
7. Finish.

Thomas Brown 2133 RUHS.

Directions. (a)
1. Build a good clean fire.
2. Get a piece of stock that has not been burned.
3. Bevel one end.
4. Bend about 1/2 of the beveled end back for welding.
5. Weld.

Directions. (b)
1. Make another weld like (a) above.
2. Bevel the end, bend, and weld again.
CONTRACT II

Project 2

Eye-pin and Ring - scale full-size
stock: 8 ft Rd - 7 1/2 (Ring)
8 ft Rd - 6 1/2 (Eye-pin)

Directions:

A. Eye-pin:
1. Get the stock.
2. Build a welding fire.
4. Layout and mark the stock as follows:
   a. 1" for the scarf.
   b. 3/4" for the eye.
5. Up-set the stem about 1/2" from the eye stock.
6. Draw the scarf.
7. Bend the eye.
8. Weld the eye.

B. Ring:
1. Bend the ring.
2. Form the scarf.
3. Slip the eye pin on and weld.
CONTRACT II  Project 3  Group 1
Required:  Chain Links  Stock- 3/8" Rd- 6" L. 3 Pcs.
3 Connected Links  Scale: Full Size

Directions:
1. Get out stock.
2. Build a good clean fire.
3. Bend all three pieces of stock into the proper sized "U" shape.
4. Make a practice weld with stock from the scrap box.
5. Scarf and weld two of the required links.
6. Scarf the third link.
7. Place the welded links on the third one and bend the scarfs together.
8. Weld the link.

Russell Woodard
P.U.H.S. 3-2-33
Project 4
Lap Weld (Exercise) Scale full size
Stock: Use scrap if possible.
Required: One good weld of each kind.
Directions:
See operation sheet for welding

Round Stock

Flatoir Square Stock

Rotated view of face of scarf

Bill Fisher - P.U.H.S.
Project-1

Wagon Wrench
Stock \( \frac{3}{8}'' \times 1\frac{1}{2}'' - 6'' \),
\( \frac{1}{2}'' \) Rd. - 10''.

Directions
1. Up-set and form scarfs for a T-weld
2. Make the weld
3. Bend as required
4. Cut the stem the proper length
5. Finish

Thomas Brown  RUHS  Scale 6'' = 1'
CONTRACT II Project 2
Soldering Copper Stock: 3/8" Rd. - 13" L. - 1" Sq. - 3 1/2" L. Copper
Group 2
Scale: Full Size

Directions:
1. Make a welded-eye on the end of the 3/8" round stock and shape it as required.
2. Draw the tang.
3. Point the copper.
4. Drill the hole in the copper.
5. Form the grooves.
6. Assemble.

Russell Woodard  
P.U.H.S. 3-7-33
Directions
1. Draw the tines
2. Form a flat scarf on the short stock
3. Up-set the body so that it will not be drawn under size while welding
4. Bend and weld the handle
5. Twist the body
6. Finish

Stock \( \frac{3}{8} \) sq. lpc. - 40" L.
lpc. - 8" L.

Thomas Brown  P.U.H.S.
CONTRACT II

Directions
1. Make the welded eye.
2. Cut off the surplus stock.
3. Lay out the flat stock.

Project 4
Stock $\frac{3}{8} \times 1 \times 3\frac{1}{2}$
$\frac{3}{8}$Rd. convenient length

- $1\frac{1}{4}$
- $3\frac{1}{8}$

fuller and draw as follows.
4. Draw ends to $\frac{3}{8}$ round and cut to the required length.
5. Bend the ends as required.
6. Punch the hole.
7. Assemble the eye and body.
8. Weld and finish.

By Thomas Brown P.U.H.S.
Directions:
1. Lay-out, shoulder and draw the jaws as indicated by the sketch.
2. Weld on the handles.
3. Bend and form the jaws.
4. Punch the eyes.
5. Assemble.
CONTRACT II

Project 2

Ice Tongs

Scale 3' = 1'

Directions:

1. Make the jaws.
2. Spread, draw and weld the handle.
3. Connect a jaw to each end of the handle with a welded link.
4. Rivet the jaws together.

Stock:

Handle \( \frac{7}{16} \) Rd. 8" L.
2 Jaws \( \frac{1}{4} \times \frac{3}{4} \) - 18 L.
2 Links \( \frac{1}{4} \) Rd. 6" L.

Drawn by R.L. Benckendorf 4063
P.U. H.S. 3-7-33.
CONTRACT II

Project 3

Chain (13 Links) - Ring - Welded Hook.
Stock 3/8" R. 6" L. 10 pc.
7/8" R. Length to be figured - Ring
1/2" R. 9 1/2" L. - Hook

Directions:
1. Make two sets of three connected links
2. Join the sets forming a chain of 7 links
3. Make the ring
4. Draw enough of the hook stock to 3/16" round to form the scarf and the eye
5. Weld the eye and bend the hook
6. Connect the ring and hook to the chain with the two remaining links

Bill Fisher P.U.H.S.
CONTRACT II

Project - 4

Group - 3

Flat Jawed Tongs

Cut the stock in the middle after jaws are forged

Directions
1. Shoulder and draw the jaws.
2. Weld on the handels.
3. Punch the eyes.
4. Assemble.
OPERATION SHEETS

FOR CONTRACT II
TWISTING

Introduction.

Twisting consists of turning one end of a piece of stock on its own axis while the other end is held stationary. The whole or any part of the bar may be twisted. Twisting is usually done for ornamental purposes, or to get flat stock to fit the required surfaces as for a beam strap.

Wrought iron or mild steel may be twisted either hot or cold. One-half inch stock, and smaller is usually twisted while cold unless it has been heated or forged. Stock which has been heated or forged should be twisted while hot. Figure 2 illustrates some common effects produced by twisting.

Directions.

1. Cold twisting.

Use chalk or soap-stone to mark the ends of the section to be twisted.

Place the stock in the vise in a vertical position with the section to be twisted extending above the jaws of the vise. Long stock must be held horizontally.
Fit a monkey wrench at the other end of the section to be twisted and twist the required amount. Figure 1.

2. Hot twisting.

Use a center punch to mark the section to be twisted.

Heat the section to be twisted to a uniform red heat. A higher heat may be necessary for large stock.

Place the stock in a blacksmith vise the same as for cold twisting.

If the stock is 3/8" or smaller, do the twisting with tongs that fit correctly. For larger stock, use a monkey wrench. Rapid work is necessary because the vise and wrench will cool the stock and produce an uneven twist.

3. Straightening.

Much straightening can be done in the vise by bending with a wrench, or by hand.

The stock may be straightened on a block of wood with a fuller or round rod. The fuller and block of wood are used to prevent marring the twist.

Cold stock may be kept straight by twisting it inside of a piece of pipe. The pipe must be cut the length of the required twist. This is advisable only when many of the same length twists are to be made. Never use pipe when twisting hot stock.

Questions.

1. Why should iron not be marked with a chisel or heavy punch mark when laying out for twisting?

2. Why is a uniform heat necessary for twisting?

3. Why should hot stock be held in a blacksmith's vise instead of a bench vise for twisting?

4. What could be done to correct an uneven twist in a heated piece of stock?

5. What safety precautions should be observed when twisting?
References.


CHIPPING AND FILING

Introduction.

The term "chipping" implies cutting stock with a cold chisel. Some jobs done with the cold chisel are as follows: cutting light stock in two, cutting sheet metal, cutting stock from a bar as in the forming of a key-way, and shearing off rivets. The term is more closely associated with cutting cast iron. Filing implies the smoothing and finishing of stock with a tool having many teeth called a "file".

Directions.


Cutting sheet metal. Sheet metal may be cut with a chisel by placing the stock in a vise. The line for cutting is placed even with the jaws of the vise. If the sheet is too large to be held in a vise, place it on a cutting block and cut along the lines until you can break out the piece of stock needed.

Cutting bar stock or cast iron. Place the stock in a vise in a convenient position. Chip the metal off as required.

(Note.) Grind the chisel as it is needed. Accurate chipping is impossible if the chisel is not sharp and correctly ground.

Caution: Never allow anyone to be in a position where chips from the chisel may strike them. Hold the chisel in your hand so that its head is next to the heel of your hand (by your little finger). Watch the cutting edge of the chisel, and not the head or your hand.


Press down on the file with enough pressure to get it to cut. If it scratches or shows pin marks remove the pins from the teeth of the file and do not press so hard next time. Push the file with your body, rocking back and forth on the feet. Use the arms to hold the file in the proper position. Do not press down on the file during the return of the stroke. Figure 1.
Draw filing. Figure 2.

Hold the file at right angles to the stock. This method of filing is effective for giving a finish after cross-filing.

Cautions: Never use a file without a handle. Use a course file for roughing out and a fine one for finishing. Do not rub your hands on the surfaces being filed. Use copper, thin wood, or pasteboard to protect the finished surfaces of the work from the vise jaws.

Questions.

1. Why is it safest to hold the chisel with the head next to the heel of the hand?

2. Why should the head of a cold chisel be finished with a chamfer and not allowed to become mushroomed?

3. Why should a cold chisel not be used on hot metal?

4. Would there be any advantage in cross-filing a piece in different directions?

5. What is the effect of pressing too hard on a file?
6. Should a file be used on hardened steel? Why?

7. Should files be piled into a drawer for storing? How should they be stored?

8. Why should your hands not be placed on the surfaces being filed?

9. When should draw filing be used? What are its advantages?

10. What safety precautions should be observed?

References.

DRILLING

Introduction.

Drilling consists of making a hole in stock with a tool called a drill. The drill is made to cut by being turned under pressure with a machine called a drill press. Some work in forging requires drilling if it cannot be punched accurately. In most cases a hole can be punched more quickly than it can be drilled.

Directions.

1. Locate the center for the hole with the measuring tools and the scribe.

2. Center-punch the mark very lightly, and if great accuracy is required, test the location of the center with a divider. If the punch mark is not properly located, lean the punch and drive the hole to the proper location.

3. Drive the center-punch into the metal enough to form a pilot for the drill point.

4. Secure the proper size drill and place it in the drill press.

   Straight shank drills must be held in a drill chuck. Use the chuck key to adjust the chuck.

   Taper shank drills must be held in the tapered hole in the end of the drill press spindle.

5. Set up the work on the drill table.

   Pieces that are small or difficult to hold should be clamped in a vise. If a vise is not handy, a large monkey wrench may be used as a substitute. Bars which are large enough to be held in the hand without danger of jerking loose may be drilled without clamping.

6. Adjust the belt on the cone pulley to give the proper cutting speed. Follow the directions given on the chart at the drill press.

7. Use a cutting compound to prevent burning the drill while drilling wrought iron, mild steel, or
tool steel. Do not use the compound when drilling cast iron, brass, copper, or any soft metal. The compound acts as a cooling agent for the drill.

6. Apply sufficient pressure on the feed lever to cause the drill to cut or feed into the metal. If the drill squeaks, it probably needs regrinding. Feed the drill very slowly and carefully as it nears the bottom of the stock. Most drills are broken as the point passes through the metal.

9. Remove the drill from a chuck by opening the jaws of the chuck with the key. If a taper shank drill is used, remove the drill from the spindle with a drift key.

10. Clean the drill press of all compound and chips before leaving it.

Questions.

1. Why should drills be run at the proper cutting speed?

2. Why are the small size drills run at a higher r.p.m. than the larger drills?

3. Why should stock that is to be drilled be allowed to cool slowly?

4. What conditions may cause a drill to break?

5. Why should small pieces be clamped in a vise or wrench while being drilled?

6. What would probably be the result if you were attempting to hold a small piece with your hands and it caught on the drill?

7. What safety precautions should be observed?

References.


FORGE WELDING

Introduction.

Welding implies a cohesive union between two or more pieces of like metal. Even though much welding is done with gas and electricity, forge welding still has an important place in metal working. It is more economical. Much practice is necessary for skill and reliability.

General Directions.

1. Remove all clinkers from the fire. They cause dirt to enter the weld which usually results in failure. The fire should not contain small pieces of coke that blow from the fire.

Have a good supply of coke on the fire, and keep the sides well banked with green coal. The center of the fire should be about six or seven inches deep. Do not allow any green coal to get into the center of the fire. It contains some sulfur.

2. Form the scarf. Usually it is necessary to upset the metal before forming the scarf.

3. Place the stock to be welded in the fire so that it is covered with about two inches of fire and at least four inches of burning coke between the iron and the tuyere.

4. Heat the stock slowly until a good yellow heat is obtained.

5. Take the pieces from the fire and sprinkle some flux over the surfaces to be welded. Just cover the surfaces with flux. It is not necessary to pile the flux up on the metal. Return the stock to the fire.

6. Gradually increase the heat until a nearly white heat appears. The surface of the scarfs should appear to be wet with molten flux.

7. Remove the stock from the fire quickly as possible, and tap the pieces lightly over the edge of the anvil to jar off surplus flux.

8. Place the pieces in the welding position and tap
them lightly to get them stock. Then increase the force of the blows to complete the weld. The scarfs must be closed from each side.

9. Reheat, if necessary, and refine the grain by hammering lightly all over the welded section. Continue the hammering until the stock cools to a dark red.

10. Allow the stock to continue cooling by placing it at the side of the forge. Do not plunge it into water.

(Note.) Make the weld with as few heats as possible.

Questions.

1. Why should the fire be clean?
2. Why is a deep bed of coke necessary?
3. Why should the stock be covered with fire when being heated?
4. How does flux aid in the welding operation?
5. Why should the stock be heated slowly at first?
6. Why should the weld be struck lightly at first?
7. What is the effect of hammering the weld lightly to finish it?
8. Why should a welded section be allowed to cool slowly?
9. What classes of iron can be welded in the forge?
MAKING OPEN WELDS

This term or classification applies to lap-welds, T-welds, angle welds, etc. Two separate pieces of stock are joined by welding.

Directions.

1. Study the general directions for welding.

2. Upset the end of each piece to be welded until it is one and one-fourth times as large as the body of the stock.

3. Draw a scarf on the end of each piece. Figure 1.

4. Get a uniform yellow heat on each piece. This heat should extend back of the scarfs about three or four inches so that the sections to be welded will not be cooled by the stock.

5. Remove the pieces from the fire and apply some flux to the scarfed surfaces.

6. Return the pieces to the fire so that they lay close together with the scarfed surfaces up.

7. When the flux has turned to a yellow, and is stick-
ing to the iron, turn the pieces over in the fire so that the faces of the scarfs are down.

8. Gradually increase the heat until a welding heat is obtained. (Note) Each piece must be at the same uniform heat throughout the parts to be welded.

9. Take both pieces from the fire and knock off the dirt and surplus flux over the edge of the anvil.

10. Lay the one in your right hand across the face of the anvil with the face of the scarf up. (Right-handed procedure.)

11. Place the piece in the left hand on the near edge of the anvil. Turn the scarf down and rest it on the other piece of stock so that the scarfs are properly lapped. (Figure 2.) A helper may assist by handling one piece of stock from the back side of the anvil.

12. Release the stock in the right hand, if working without a helper, and pick up the hammer. Strike a few light blows to get the weld stuck.

13. Strike heavier blows and close the tip of the scarf that is on top. Turn the stock over and close the
scarf on the other side.

(Note) All scarfs should be closed from the inside outward so as to force out as much flux and dirt as possible.

14. Turn the stock and close the sides of the scarfs.

(Note) All of the work of closing the scarfs must be done with the stock at a welding heat. Reheat the stock if necessary after the pieces are stuck. The complete operation should, however, be performed with one heat.

15. Finish the weld as explained in the general directions.

Questions.

1. Why should upright blows be used when hammering a weld together?

2. Why should each piece be at an equal and uniform heat?

3. Why are the pieces placed in the fire with the faces for the scarfs up and then turned over while taking the welding heat?

4. What would probably be the result if the scarfs were closed with angle blows?
MAKING CLOSED WELDS

This coassification applies to welds such as those used for chain links, eye-pins, etc. The scarfs are held together by the one piece of stock.

Directions.

1. Study the general directions for welding.

2. Calculate the amount of stock that will be required.

3. Bending and scarfing.
   a. For chain links. Figure 3.

   
   ![Figure 3](image)

   Bend the stock into a "U" shape.

   Form a scarf on each end. This may be done on the edge of the anvil or with the peen of the cross peen hammer.

   Bend the scarfed ends so that the scarfs are lapped properly.

   b. For rings. Figure 4.

   Bend as indicated.
Form the scarfs as for a chain link, and bend them ready for welding. For large rings the stock should be upset and scarfed on each end before bending. In this case the scarfs should lap as for an open lap weld.

*Figure 4*

*Figure 5*

(a) Length needed for eye

(b) 

(c)
c. For a welded eye. Form a pointed scarf on the end of the stock.

Lay out from the back of the scarf the amount of stock needed for the eye and mark it with a center punch. The stock forming the stem may be upset some to allow for closing the tip of the scarf.

Bend the eye. Follow the steps as shown in Figure 5.

4. Weld and finish.

Questions.

1. What is the purpose of forming scarfs?

2. When making up a chain, why should you make two separate links and then join them with a third?

3. Why must you work very rapidly when closing the scarfs after the welding heat has been taken?

References.


Introduction.

The operation of sharpening tools, or smoothing surfaces on a rotating emery or carborundum wheel is called grinding. A pair of goggles should be worn to protect the eyes. At times it is necessary to remove surplus stock by grinding it away. Most grinding consists of shaping and sharpening tools.

Directions.

1. Determine what grinding is necessary.

2. Grinding cutting edges. Figure 1.

Hold the tool so that the proper angle will be formed by the stone. Have a finger near the cutting edge so that you will feel the tool heating and not allow it to become heated enough to destroy the temper.

Hold the tool against the stone and grind it the required amount. Examine the ground surface to be sure that the proper shape is being formed. Cool the tool if it feels hot to the fingers.
(Note) Always grind against the cutting edge.


Grinding surfaces by hand is very difficult. A better job can usually be done with a file. Hold the stock in the proper position and then press it against the stone. Jobs which are to be hardened and tempered should be ground before heat treating. A piece of work requiring a long straight edge, as for a large cutting tool, may be ground on the side of the stone. The side should never be used except for this purpose.

(Note) Always move the piece being ground so as not to form a groove in the stone.

Questions.

1. Why should one avoid forming grooves in a stone while grinding?

2. Would it be a good practice to always stand at the side of a stone while grinding? Why?

3. Why should a grinder be equipped with a coarse and fine stone?

4. What should be done if a stone is found to be running eccentric?

5. What is the purpose of the rest on the grinder? How far should the rest be from the surface of the stone?

6. What safety precautions should be observed?
Introduction.
Threading consists of cutting spiral grooves called threads. External threads as on a bolt are cut with a tool called a die. Internal threads as in a nut are cut with a tool called a tap. Dies are operated with a tool called a stock. Taps are operated with a tool called a tap wrench. All threading must be done while the stock is cold and thoroughly annealed or softened.

Directions.
1. Internal threading.
   a. Prepare the work by drilling or punching a hole the required size for threading. (Refer to a table of tap and drill sizes.)
   b. Select the tap and place it in the tap wrench.
   c. Hold the tap straight with the hole and start it by turning the tap to the right, or clockwise. Hold the hands near the center of the wrench and press toward the hole.
   d. When the tap has started apply some oil or cutting compound to keep it cool and to prevent sticking in the work.
   e. Turn the tap into the hole about one turn and then back it up to break and free the chip. Continue the operation until the hole is tapped. Use an equal pressure on each end of the wrench.

Caution: Care is required in using taps because they are very hard and break easily if not handled correctly. Special care should be observed when tapping a hole that does not extend through the stock. The tap will break if forced against the bottom of the hole.

2. External threading.
   a. Prepare the surface of the metal by removing any heavy scales. Check with calipers to see that the diameter of the work is the correct size.
b. Select the proper die and set it in the stock.

c. Start and operate the die in the same manner as the tap.

(Note.) The threading jaws in a die are adjustable. If a thread is not cut properly consult the instructor. If the stock is the correct size and the tool is operated correctly, a smooth clean-cut thread will be formed.

Questions.

1. How may a broken tap be removed?

2. What precautions should be observed when tapping a hole which does not extend through the stock?

3. Why must jobs be thoroughly annealed before threading?

4. What is meant by the letters U.S.S.? S.A.E.?

5. Why should heavy scales be removed where threads are to be cut?
Introduction.

Projects or jobs are usually finished for the purposes of preservation and appearance. Jobs which are to be exposed to the weather should be painted with two coats of red lead in linseed oil before the finishing coats are applied. When ornamental iron is painted the purpose should be to enrich the natural beauty of the iron and not to disguise it. Some ornamental iron work on the market is practically ruined by being painted with gaudy colors.

Directions.

1. Flat black.
The simplest method of producing a flat black finish is by painting. Parts of the project may be bronzed very lightly for accent.

   Clean the project thoroughly. All grease, oil, and moisture must be removed.

   Apply the paint with a brush. Rub it out well. The paint is applied to produce a uniform black color.

2. Smoked.
This is a finish that was used extensively in the past, and is still popular for antique work. It retains the natural oxidized appearance and resists rusting.

   Apply a light coat of linseed oil.

   Heat the project sufficiently to burn the oil into the surface of the metal.

   Rub off the loose soot with a gunny sack or similar rough cloth. The more you rub this finish the better it looks.

3. Natural.
Apply a coat of wax or thinned linseed oil.

   Rub off as much of this as possible.

   The wax or oil is used to prevent rusting. The project must be refinished occasionally because the finish is not permanent. Clear lacquer may
be used.

4. Polished.  
This finish is suitable for tools. Grind, file, and polish the tool until all the surface shows the natural silvery gray color of the iron. The surfaces must be straight and smooth.

Apply a thin coat of lubricating oil to prevent rusting.

Mild steel tools that are case-hardened have a grayish-blue mottled appearance due to the special treatment. This should be protected from rusting the same as the polished steel.

A special polished steel effect may be produced with grinding compound and a stick placed in the drill press. This produces little highly-polished circles.

5. Special or novelty finishes.  
Peened. This is produced by hammering all surfaces of the stock with a ball peen hammer. It may be finished flat black, or with the high spots bronzed or polished. The bronze powder must be used sparingly. An attractive finish may be secured by lightly polishing the high spots and then applying a thin coat of lacquer.

Painting or lacquering with contrasting colors is not approved.

6. Antique.  
This finish may be produced by dusting rotten stone over the wet paint. After the paint has dried, lightly brush off the loose rotten stone.

(Note) The appearance of ornamental iron projects may be enriched if the bars of stock are hammered lightly with the face of the hammer before being assembled. This resembles the work of the old craftsmen.

Most novelty finishes are not considered as being good by many noted art smiths. They rely upon the natural beauty of the iron and quality of the work for the desirable appearance.
Questions.

1. How should the surface of a project be prepared for painting?

2. Why should flat black paint be rubbed out well? What is the function of the paint?

3. What should be the fundamental purposes of ornamental finishing?
INFORMATIONAL TOPIC GUIDE-SHEET

Contract II

The following list of topics and references are to be used as in Contract I.

The references suggested for study are as follows:

A. Schwarzkopf, Ernest, "Plain and Ornamental Forging".

B. Selvidge, R. W. and Allton, J. M., "Black-smithing".

C. Ilgen, W. L., "Forge Work".

D. Littlefield, J. D., "Notes for Forge Shop Practice".

E. Richards, W. A., "Forging of Iron and Steel".

The letters "A", "B", "C", etc., given after each topic indicate respectively the references that may be used for sources of information.

A. Tools and Equipment.

1. The drill press.
2. Drills.
3. Files. (B) p. 49, (C) p. 27.
4. Threading tools. (B) p. 147.
5. Grinders.
7. Dividers.
8. Center punch.
9. Chisels.

B. Technical and Related Information.

2. Sharpening tools. (A) p. 149.
3. Fitting hammer handles.
4. Re-shaping tongs.
5. Lubrication of machinery.
6. Relining forges.

7. Types of finish.

8. Types of welds. (A) p. 77-87, (C) p. 50-56; 69-73, (D) p. 27-31, (E) p. 95-107.


15. Production of cast or pig iron. (C) p. 168-173, (E) p. 19.

INFORMATIONAL TEST MATERIAL

Contract II

A. Twisting.

1. Twisting is usually done for ornamental purposes.

2. Wrought iron or mild steel may be twisted while either hot or cold.

3. Stock which has been forged is usually twisted while hot.

B. Chipping and filing.

1. Pins are formed in a file by pressing too hard on the file.

2. A file should not be made to cut on the return stroke.

3. Draw filing is used for smoothing or finishing a filed surface.

4. A coarse file should be used for rough filing.

5. A file should not be used for hardened steel.

C. Drilling.

1. Straight shank drills must be held in a drill chuck for drilling.

2. Taper shank drills must be held in the spindle of the drill press for drilling.

3. A drill that is not operated at the proper speed may be burned or broken.

4. A cutting compound should be used when drilling all metals which form a shaving while being drilled except copper, brass, aluminum, lead, etc.

5. Cutting compound aids in cooling the point of the drill.

6. A drift key should be used for removing a taper shanked drill from the drill press spindle.
7. Large drills should be operated more slowly than small ones.

8. Stock that has been heated should be allowed to cool slowly before being drilled.

9. Factors which may cause a drill to break are:
   a. Grabbing as it passes through the stock.
   b. Feeding too rapidly.
   c. Not sharpened correctly.
   d. Stock not set properly.

D. Welding.

1. A weld is a cohesive union between two or more like pieces of metal.

2. Conditions which are necessary for good welding:
   a. Stock must be properly scarfed.
   b. The fire must be clean and properly shaped.
   c. The pieces of stock must be equally heated and plastic.
   d. The pieces of stock must be hammered or pressed together.

3. Flux aids in welding by:
   a. Lowering the melting point of the iron oxide.
   b. Forming a fusible slag over the metal which prevents further oxidation.

4. Welded sections should be hammered lightly as they cool for refining the grain.

5. Welded jobs should be allowed to cool slowly.

6. Green coal must be kept from the center of the fire while welding.

7. Metals which can be welded at the forge:
   a. Wrought iron.
   b. Mild steel.
   c. High carbon steel.
      The determining factor is the per cent of carbon present. The iron with the lower carbon content welds the easier.

8. Straight upright blows should be used for closing the scarfs of a weld.

9. Borax is one of the principal parts of most welding fluxes.
E. Grinding.

1. Care must be observed when grinding tempered tools to avoid burning or destroying the temper.

2. Always grind against the cutting edge.

3. Eccentric stones should be dressed down so that they will run smoothly.

4. A grinder rest should be placed as close to the stone as possible without touching the stone.

F. Threading.

1. Internal threads are formed with a tap.

2. A tap wrench is used for the operation of a tap.

3. External threads are formed with a die.

4. Dies are operated with a stock.

5. Holes which are to be tapped must be drilled or punched smaller than the required threaded size.

6. Threads may be either left or right-handed.

7. Oil or cutting compound should be used when using threading tools and the same rule applies to this as for drilling.

8. Bolts and nuts are made according to standard sizes.


10. S.A.E. is the abbreviation for Society of Automotive Engineers.

G. Finishing.

1. Iron may be finished for preservation or appearance.

2. Jobs that are to be exposed to the weather should be given protective coats of red lead before the top finish is applied.

3. The surfaces that are to be painted must be free from oil, moisture, and other foreign material which may prevent the paint adhering to the metal.
4. Painting of ornamental iron should be for the purpose of enriching the natural beauty of the work.

5. Types of finishes:
   a. Flat black
   b. Smoked
   c. Bronzed
   d. Lacquered
   e. Polished

H. Wrought iron.

   1. The production of wrought iron is universally known as puddling.

   2. Steps in the puddling process:
      a. Melting down
      b. Mixing
      c. Boiling
      d. Balling

   3. Wrought iron has a silvery gray color.

   4. Wrought iron is the most pure form of iron used in the trade.

I. Cast or pig iron.

   1. Cast or pig iron is produced in a blast furnace.

   2. Three materials charged into the blast furnace in smelting of iron ore; (a) Iron ore, (b) Lime stone, (c) Coke.

   3. Two materials drawn from the blast furnace in the smelting of iron ore; (a) Pig or cast iron, (b) Slag.

   4. All iron must be made into pig iron before it is further refined into steel or wrought iron.

K. General.

   1. Use chalk or soap stone to mark lay-outs on stock that is to be worked while cold.

   2. Use a center punch to mark stock that is to be worked hot.

   3. Stock should be marked lightly with a center punch so that the work will not be marred.
4. The blacksmith's vise should be used for holding work for forging.

5. If hot metal is cut with a cold chisel, the heat of the metal will draw the temper of the cold chisel.

6. Stock allowance for welding usually amounts to the thickness of the stock at the welded section.
APPENDIX E.

CONTRACT III, WITH OPERATION AND INFORMATION SHEETS.
APPENDIX E.

CONTRACT III, WITH OPERATION AND INFORMATION SHEETS.

Introduction.

Contract III is designed to give you an introduction to the work in Forging that you may take after satisfactorily completing the elementary course. This contract offers an opportunity to do work in the fields of tool making, ornamental forging, and general forging. This contract should aid you in determining whether to continue with forging, or to change to some other type of shop work. Your shop work for this contract should consist of making projects involving a personal interest. Choose projects that you wish to make. They should inspire you to work to capacity due to a desire to make them.

Shop Work.

Introduction:

The shop work for this contract offers an opportunity to apply the information and skill acquired in the preceding contracts. A new type of work--tool making is introduced to give you an opportunity to have experience in that line of work.

As in the preceding contracts, three groups of projects are offered. The difficulty and amount of work involved in making these projects varies greatly. You should be careful in choosing your projects so that
you will not choose one that is too difficult. Consult your instructor with each case before making your working plans.

Directions.

Study all the suggested projects and pick out the one you wish to make. Ask your instructor if he thinks you can make it. If he "O.K.'s" your selection, prepare plans for the project. If not, choose another that is not too difficult. Follow the directions as given on the informational sheet prepared for the type of project you wish to make. If your project is in the field of tool making, study the instruction sheet for tool making. If your project is in the field of ornamental forging, or general forging, study the instruction sheet for ornamental forging. In each case you must have a project card filled out, and a working drawing with the necessary full size details checked by the instructor before actual construction may be started.

Study the instruction sheets very carefully. The instruction sheets for this contract are informational. They tell you how to proceed with ornamental or tool steel projects. They will help you in making your project plans.

If there are any projects in either of the preceding contracts that you wish to make, you may do so.
SUGGESTED PROJECTS

FOR CONTRACT III.
CONTRACT - III

Project - 1
Table Lamp

Group - I

Material:
Base 20 G. M.S.
Post 3/8 x 3/4 M.S.
Bracket 3/8 x 1/2 M.S.
Rivets 5/32 x 1/2 R.H.
Socket
Pipe nipple 5/8 x 1/2

Directions:
1. Make full size drawing.
2. Fill out project card.
3. Make the base.
4. Make the post.
5. Make the bracket.
6. Assemble.
7. Finish.
**Directions:**

1. Make a full size sketch of the project.
2. Fill out the project card.
3. Lay out posts for the scrolls.
4. Lay out posts for the cross bar.
5. Punch the posts for the bar.
6. Split and draw out the stock for the scrolls.
7. Draw chisel points on the other ends.
8. Bend the scrolls.
9. Rivet the bar to the posts.
10. Paint two coats of flat black.
Project 3
Center Punch
Stock: 3/8" Oct. 3/4" L. T. S.

Required:
1. Repair a punch.
2. Make a punch.

References:
Schwarzkopf, "Plain and Ornamental Forging". Page: 146.
Littlefield, "Forge Shop Practice". Page 60.
CONTRACT III

Project 4
Cold Chisel
Stock: $\frac{1}{2}$ Oct. 5" L. T.S.

Required:
1. Repair a chisel.
2. Make a chisel.

References:
Ilgen, "Forge Work" Page 108.
Project 1
Smoking Stand

Stock:
Post - 1" x 3" M.S.
Legs - 1/4" x 1/4" M.S.
Handle - 1/8" x 1/2" M.S.
Tray - 20 gauge Steel 3" D.
Rivets - 1/8" x 4"  

Directions:
1. Make a full size drawing of the parts.
2. Fill out the project card.
3. Make the parts.
4. Assemble.
5. Finish.
Project 2
Camp Fire Grate

Stock:
- 2 pc. \( \frac{3}{8} \times \frac{3}{4} \times 3" \) - 24" Angle.
- 11 pc. \( \frac{4}{5} \) Rd 15\( \frac{1}{2} \)" L.
- 4 pc. \( \frac{5}{6} \) Rd 12\( \frac{1}{2} \)" L.

Directions:
1. Lay-out and drill the angle iron.
2. Up-set, draw, and drill the cross-bars.
3. Make the legs.
4. Assemble.
Project 3

Hardie

Stock: ¼" x ½" (Convenient length) T.S.

Reference:
- "Plain and Ornamental Forging" by Schwartzkopf Page 180
- "Forge Work" by Ilgen Page 111

Scale: 3" = 1"

Group 2

CONTRACT III

Russell W. Ward 5-24-33
Project-4
Boring Tool
Stock: \( \frac{1}{2} \)" x 1" convenient length

References:
Schwarzkopf, "Plain and Ornamental Forging". Page 158.
Ilgen, Forging. Page 103
CONTRACT III

Project 1
Fireside Bench.

Group 3

Size:
Top - 15" x 32"
Height - 19"

Stock:
Feet - $\frac{1}{4}" \times \frac{3}{4}"$ M.S.
Legs - $\frac{1}{4}" \times \frac{3}{4}"$ M.S.
Braces - $\frac{3}{8}" \times \frac{3}{4}"$ M.S.
Rivets - $\frac{1}{16}" \times \frac{3}{4}"$ R.H.
Top - $\frac{3}{4}"$ Pine - Upholstered.

Directions:
1. Make a full size sketch of the parts.
2. Fill out the project card.
3. Make the various parts.
4. Assemble.
5. Finish.
6. Have the top upholstered.
CONTRACT III Group 3
Project-2
Floor Lamp
Stock:
Legs 2"x1" or 2" 3/4"
Post 2" Rd. or Sq.
Bracket 2" x 3/4"

Directions:
1. Make full size sketch of various parts.
2. Fill out the project cards.
3. Make the post (Do not bend the flame ornament)
   Thread 1" of the post at bottom.
4. Drill a 7/8" hole in one leg at center and a 1/2" hole in the other.
5. Bend the legs.
6. Make the flower ornament.
7. Punch, bend and assemble the bracket.
8. Assemble.
9. Make the flame ornament.
10. Finish.

Height 54"
CONTRACT III
Group 3
Project 3
Hot-Cutter
Stock:
1\(\frac{1}{4}\) sq. convenient length T.S.

References:
"Plane and Ornamental Forging" by Schwarzkopf page 167. "Forge Work by Illgen page 109"
CONTRACT III

Project 4
Riveting Hammer
Stock: 1" sq convenient length T.S.

Reference:
"Plane and Ornamental Forging" by Schwarzkopf page 66.
"Forge Shop Practice" by Littlefield page 67.

Drawn by Ray Nelson RU.H.S. 5/3/33
INFORMATIONAL SHEETS FOR

CONTRACT III.
You may also make original projects if they are not too difficult and do not involve new operations.

Some tool steel projects are offered as an introduction to the work. The information relative to working tool steel will be given only as required for the making of the projects suggested for the contract. If more extensive work in tool steel is desired it will be necessary to register for Tool Making and Tempering, which is an advanced course.

The projects for Contract III are not scored as for Contracts I and II. However, grades will be determined by comparison. The amount of work involved, and the quality of the work will be the guiding factors.
MAKING ORNAMENTAL IRON PROJECTS.

Introduction.

The following general instructions are given to aid you in planning and making projects. Study them carefully so that you will know how to proceed.

Directions.

1. Choose the project.

2. Make a pencil sketch showing general design. Have this checked by the instructor.

3. Develop full size details of the necessary parts and a working drawing of the complete project.

4. Fill out a project card as you have been previously instructed.
   a. Make out a bill of material.
   b. Determine what operations must be performed and list them on the card. If there are any you are not familiar with, or are new to you review the operation sheets of Contracts I and II. They may help you.
   c. Make a project plan.

5. Make the various parts of the project. Have each part "O.K'd".

6. Assemble the project.

7. Finish.

8. Present it to the instructor for a final checking.

Questions.

1. Why is it necessary to develop plans for making a project?

2. What is meant by proportions in design?

3. What is considered as acceptable proportions?

4. Name some types of ornamentation common to iron work.

5. How may hand-made ornamental iron pieces be distinguished from the machine-made pieces?
6. Why should every piece in a project be very carefully checked for dimensions, straightness, etc., before assembling?
Introduction.

As explained in the general directions for shop work the instructions relative to tool making will be quite limited. The following directions will assist you in planning your projects.

Directions.

1. Make a working sketch of the project showing all dimensions.

2. Study all references given on the blueprint that may be found in your text.

3. Fill out a project card.
   a. Make out the bill of material.
   b. Prepare the list of operations.
   c. Prepare the project plan.

4. Check out a bar of stock from the tool room and cut off the amount of stock needed for the project. Tool steel must always be heated slowly in a deep coke fire. Cut the stock on a hardie. Cool the remaining part of the bar slowly in water and return it to the tool room immediately.

5. Do the necessary forging. Make all forgings as accurate and smooth as possible. This will save much time later.

6. Place the project at the side of the forge and allow it to cool slowly until no heat colors appear in a place having poor light. Complete the cooling process in water. If the project is allowed to cool slowly, it will be soft and will file easily.

7. Cross-file the project with a coarse file to remove the scale and true up all surfaces. Cross-file and then draw-file all surfaces with a fine file.

8. Do the necessary hardening.


10. Grind the cutting edge. Test. If the tool is a hammer, test the face and peen with an old file. The file should not cut.
11. Polish the project with a polishing board or the polishing wheel.

(Note) If you should desire to mark the tool with your name or number, it should be done before hardening.

Questions.

1. Why is planning necessary?

2. Why should marking and filing be done before hardening?

3. What are temper colors?

4. What is meant by annealing? Hardening? Tempering?

5. What is the forging heat for tool steel?
Introduction.

The informational topics listed below will be studied in the class room. Most of these topics have a general educational value rather than being information that can be used immediately in the shop. In most cases, specific references are not available so the topics will be discussed in class. You should keep an outline record of these discussions in your notebooks.

Topics.

1. Introduction to designing as related to ornamental forging.

2. Tool making.

   References:
   Littlefield, J. D., "Notes for Forge Shop Practice", pp. 56-57 (Omit Spring Tempering); 60.

3. History and development of metal working industry.
   a. The ancient craftsman.
   b. The centralized shop.
   c. Present status.
      (1) Machine forging.
      (2) Ornamental forging.
      (3) Welding methods.
      (4) Hand forging.

4. Qualifications, and opportunities of the trade.
   a. Entrance requirements.
   b. Training.
   c. Living conditions.
   d. Promotions.
   e. Wages.
   f. Working conditions.
g. Extent of employment.

   a. Arrangement of equipment.
   b. Personnel organization.
   c. Production and instruction organization.
   d. Health and safety.

   a. Trip hammers.
   b. Steam hammers.
   c. Welding machines.
   d. Punching machines.
   e. Presses.
   f. Drop forging.
APPENDIX F.

TESTING AND SCORING.
Tests and Scoring.

The following is a presentation of directions, score keys, and the tests for the contracts of the course in Elementary Forging. Two kinds of tests are suggested; one is a performance test, and the other is an informational test. These tests have been used with satisfactory results. The following tests are suggested ones, and should be varied from time to time as the instructor sees opportunity for improvement.

Performance Tests.

(Directions for Instructor)

The instructor should study the parts of the tests carefully so that he may understand each test project. The score keys should be studied along with the blueprints and working directions. Have enough stock cut for each part of the tests before the class assembles.

Statement of shop conditions.

When the class has assembled, read the "General directions" for the benefit of the class. Furnish each student with a blueprint of the part of the test to be used. Explain any detail that is not clearly understood. Keep in mind that this is a manipulative test and not an informational test.
Every student should know just how to proceed with the test project. Explain the method to be used for grading the test.

Tests are not furnished for Contract III. It has been found that the work requires all the time that is available. If one should wish to give a test, parts of the tests for Contracts I and II could be repeated.

The shop must be prepared for the test before the class assembles. Have the coke on the forges distributed evenly. The fires must all be dead. Have a supply of matches. Have a generous supply of shavings and kindling for starting the fires. Have each forge equipped with the following list of tools.

1. Shovel.  5. Hollow bit, flat-jawed, and link tongs that will fit the particular part of the tests to be used.
2. Rake.
3. Poker.
4. Sprinkler.

The following tools will be needed at the anvil for the test for Contract I:

1. Hammer. (Approximately 2-pound blacksmith's hammer.)
2. Hardie. (Sharp.)
3. Hook scale. (Plain scale may be used—no calipers.)
4. 1/4" heading tool. (May use 1/2" or 3/8" flat stock with a 9/32" hole drilled through it.)
5. Center punch.
6. Hot punch suitable for making a 1/2" hole. (No drift punches.)

The following tools will be needed at the anvil for the test for Contract II.
1. Hammer.
2. Hardie.
3. Hook scale.
4. Center punch.
5. Generous supply of welding flux.
6. Suitable monkey wrenches by the vises.

(Note) Two students may work at one forge and anvil. In this case the necessary additional tools must be provided. The instructor should have a piece of soap stone for marking the hot test pieces as they are turned in.

Issue one piece of stock to each student. Note the time and instruct the class to begin work. As each student turns in his test project record the time. If a student needs an extra piece of stock make a record of it. The instructor must use his judgment in answering questions after the class has started to work. Warn the class when there are only twenty minutes left for working. Give a second warning when there are only five minutes left. When the full time of one hour and fifteen minutes has passed, call time, and collect all projects whether they are finished or not.
Scoring Keys and Grading Directions.

The following keys are used for scoring the tests. A convenient form should be used for recording the results. (See report given in Section II on Application.)

Performance Tests

Contract I - Part A.

1. Size of the square stock. Assign scores according to the following table using a deviation of one thirty-second inch. (A special snap gauge is convenient for measuring the test pieces rapidly.) The correct size is three-eighths of an inch. If a test piece is not more than one thirty-second of an inch over or under size, allow ten points for the size of the square point.

<table>
<thead>
<tr>
<th>Deviation</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 1/32&quot;</td>
<td>10</td>
</tr>
<tr>
<td>1/32&quot; to 1/16&quot;</td>
<td>8</td>
</tr>
<tr>
<td>1/16&quot; to 3/32&quot;</td>
<td>6</td>
</tr>
<tr>
<td>3/32&quot; to 1/8&quot;</td>
<td>4</td>
</tr>
<tr>
<td>1/8&quot; to 5/32&quot;</td>
<td>2</td>
</tr>
<tr>
<td>Over 5/32&quot;</td>
<td>0</td>
</tr>
</tbody>
</table>

2. Size of the round stock. Assign scores as above.

3. Length of the square point. Assign scores using a deviation of one-sixteenth inch. Allow the same scores as for the size of the square stock.
4. Length over all. Assign scores using a deviation of one-sixteenth inch. (10 points highest.)

5. Appearance. Consider the following factors.
   a. Straightness of the body and points.
   b. Finish.
   c. Transition from square to round.

Assign scores according to the following table. The test pieces are arranged in groups approximating the normal curve of distribution.

<table>
<thead>
<tr>
<th>Group</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. (Best)</td>
<td>20</td>
</tr>
<tr>
<td>2.</td>
<td>16</td>
</tr>
<tr>
<td>3.</td>
<td>12</td>
</tr>
<tr>
<td>4.</td>
<td>8</td>
</tr>
<tr>
<td>5.</td>
<td>4</td>
</tr>
</tbody>
</table>

6. Total the scores.

7. Time correction. Make a distribution of the working time. Determine groupings that approximate the normal curve of distribution. Assign the following corrections.

<table>
<thead>
<tr>
<th>Group</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. (Shortest)</td>
<td>plus 4</td>
</tr>
<tr>
<td>2.</td>
<td>&quot; 2</td>
</tr>
<tr>
<td>3.</td>
<td>0</td>
</tr>
<tr>
<td>4.</td>
<td>minus 2</td>
</tr>
<tr>
<td>5.</td>
<td>&quot; 4</td>
</tr>
</tbody>
</table>
8. Burned stock. Record a correction of minus two points for each evidence of burns.

9. Retrials. Record a correction of minus two points for each retri.

10. Diamond shape square stock. Assign a correction of minus two points.

11. Defective point (split or blunt). Assign a correction of minus one point for each.

12. Total the corrections.

13. Calculate the final score.

Part B.

1. Diameter of the head. Assign scores according to the following:

<table>
<thead>
<tr>
<th>Deviation</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 1/32&quot;</td>
<td>10</td>
</tr>
<tr>
<td>1/32&quot; to 1/16&quot;</td>
<td>8</td>
</tr>
<tr>
<td>1/16&quot; to 3/32&quot;</td>
<td>6</td>
</tr>
<tr>
<td>3/32&quot; to 1/8&quot;</td>
<td>4</td>
</tr>
<tr>
<td>1/8&quot; to 5/32&quot;</td>
<td>2</td>
</tr>
<tr>
<td>More than 5/32&quot;</td>
<td>0</td>
</tr>
</tbody>
</table>

2. Length of the body. Assign scores as for the head using a deviation of one-sixteenth inch. (Point included.)

3. Size of the body. Assign scores according to the amount undersize. Use a deviation of 1/64". (10 points, highest.)
4. Appearance. Consider the following factors:

1. Straightness of the body and point.
2. Location of the head.
3. Disfiguration due to hammering and oxidation.
4. Shape of the head.

Assign points as in scoring Part A. (20 points, highest.)

5. Total the scores.
6. Time correction. Assign corrections as for Part A.
7. Burns. Assign corrections as for Part A.
8. Retrials. Assign corrections as for Part A.
9. Defective points. Assign a correction of minus one point for each.
10. Total the corrections.
11. Calculate the final score.

Part C.

1. Under size stock. Scoring consists of measuring the smallest part of the stock. This measurement can be made with a gauge prepared for this purpose, or with a caliper scale. Assign scores according to the following table.

<table>
<thead>
<tr>
<th>Amount under size</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 1/32&quot;</td>
<td>10</td>
</tr>
<tr>
<td>1/32&quot; to 1/16&quot;</td>
<td>8</td>
</tr>
</tbody>
</table>
2. Size of eye. Score the size of the eye with a plug gauge like the one shown in the following sketch.

```
<table>
<thead>
<tr>
<th>Diam.</th>
<th>1/16&quot;</th>
<th>1/8&quot;</th>
<th>3/16&quot;</th>
<th>1/4&quot;</th>
<th>3/8&quot;</th>
<th>1/2&quot;</th>
<th>5/8&quot;</th>
<th>3/4&quot;</th>
<th>7/8&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Score</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>6</td>
<td>8</td>
<td>10</td>
<td>8</td>
<td>6</td>
<td>4</td>
</tr>
</tbody>
</table>
```

Record the score for the largest size that will slip into the eye.

3. Length over all. Use a scale and square head for making these measurements. Set the square head on an inch mark and place the end of the stem against the head. Score according to the following table.

```
<table>
<thead>
<tr>
<th>Deviation</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 1/16&quot;</td>
<td>10</td>
</tr>
<tr>
<td>1/16&quot; to 1/8&quot;</td>
<td>8</td>
</tr>
<tr>
<td>1/8&quot; to 3/16&quot;</td>
<td>6</td>
</tr>
</tbody>
</table>
```
3/16" to 1/4" .................. 4
1/4" to 5/16" .................. 2
More than 5/16" .............. 0

4. Appearance. Consider the following factors comparatively.
   a. Disfiguration due to hammering.
   b. Disfiguration due to oxidation.
   c. Location of the eye.
   d. Straightness.

   Arrange the pieces in groups and assign score as before. (20 points highest.)

5. Total the scores earned.

6. Time correction. Record corrections as before.

7. Burned stock. Record corrections as before.

8. Retrials. Record corrections as before.

9. Total the corrections.

10. Calculate the final score.

   Part D.

1. Size of hole. Use a plug gauge like the one used for measuring the eye for Part C. Use a deviation of one thirty-second inch. (10 points highest.)

2. Thickness of stock around the punched hole. Score as before, using a deviation of one sixty-fourth inch. (10 points highest.)

3. Location of the hole. Measure the smallest and largest distance from the hole to the outside edge. Score
according to the following:

<table>
<thead>
<tr>
<th>Deviation</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 1/32&quot;</td>
<td>10</td>
</tr>
<tr>
<td>1/32&quot; to 1/16&quot;</td>
<td>8</td>
</tr>
</tbody>
</table>

And so forth.

4. Appearance. Consider the following factors:
   a. Location and shape of the punched end.
   b. Straightness.
   c. Finish.

Assign scores as before. (20 points, highest.)

5. Total the scores.

6. Time corrections. Assign corrections as before.


8. Retrials. Assign corrections as before.

9. Total the corrections.

10. Calculate the final score.

Contract II - Part A.

1. Size of the eye. Measure and score as for Part C, of Contract I. (10 points, highest.)

2. Undersize stock. Score as for Part C of Contract I. (10 points, highest.)

3. Appearance. Consider the following factors:
   a. Disfiguration.
   b. Location of the eye.
   c. Shape of the eye.
   d. Finish.
Assign scores as before. (20 points, highest.)

4. Strength. This scoring is accomplished by placing the test projects in a vise and bending the stem back and forth in steps of 45 degrees until the stem or the weld breaks. The following sketch illustrates the way to hold the stock in a vise, and the method of bending.

Slip a pipe over the stem until the end is about one-fourth inch from the tip of the scarf. Allow two points if the scarf appears to be stuck. Allow an additional two points for each step in the bending.

5. Total the scores.

6. Time corrections. Assign corrections as before.

7. Retrial corrections. Assign corrections as before.

9. Total the corrections.

10. Calculate the final score.

Part B.

1. Size of the stock. Score as before using a deviation of one thirty-second inch. (10 points, highest.)

2. Appearance. Consider the following factors.
   a. Finish.
   b. Straightness.
   c. Appearance of the twist.

Assign the following scores.

<table>
<thead>
<tr>
<th>Group</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. (Best)</td>
<td>10</td>
</tr>
<tr>
<td>2.</td>
<td>8</td>
</tr>
<tr>
<td>3.</td>
<td>6</td>
</tr>
<tr>
<td>4.</td>
<td>4</td>
</tr>
<tr>
<td>5.</td>
<td>2</td>
</tr>
</tbody>
</table>

3. Strength. Place the stock in a vise so that the entire welded section extends beyond the vise jaws. Bend the stock so as to shear the weld. Allow six points if the weld is holding at all. Allow an additional six points for each 45 degree bend that is made. Bend as directed for testing the weld in Part A.

4. Total the score.

5. Time corrections. Assign corrections as before.
6. Retrials. Assign corrections for retrials as before. Use of both ends of the stock is considered as a retrial.

7. Incorrect twist. Assign a correction of minus two points if the twist is more or less than one complete turn or if the twist is quite uneven.


9. Total the corrections.

10. Calculate the final score.

Part C.

1. Trueness of the ring. Use a deviation of one thirty-second inch. Assign scores on the largest and smallest measurement. (10 points, highest.)

2. Appearance. Score as for Part B of Contract II. (10 points, highest.)

3. Strength. Score as for Part D, of Contract II.

4. Total the scores.

5. Time corrections. Assign corrections as before.

6. Retrials. Assign corrections as before.


8. Total the corrections.

9. Calculate the final score.

Part D.

1. Width of the link. Assign scores as before using a deviation of one thirty-second inch. (10 points, highest.)

2. Appearance. Consider the following factors.
a. Finish.
b. Shape.
c. Size of welded section.
d. Appearance of the weld.
Assign scores as for Part B, of Contract II. (10 points, highest.)

3. Strength. Allow points according to the following cases:

<table>
<thead>
<tr>
<th>Case</th>
<th>Points</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3</td>
<td>A; ears to be stuck.</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>The link will stand hammering that would shear the weld.</td>
</tr>
</tbody>
</table>

(Hammer the link into the following shape.)

If the weld shears while being prepared for "Case 3", assign the points allowed for "Case 2".

<table>
<thead>
<tr>
<th>Case</th>
<th>Points</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>9</td>
<td>One scarf tip is broken loose, or the link is started to break due to over heating.</td>
</tr>
<tr>
<td>4</td>
<td>12</td>
<td>No evidence of weld shearing or the stock breaking.</td>
</tr>
</tbody>
</table>
(Hammer the link into the following shape.)

If the weld shears while being prepared for "Case 5", assign the points allowed for "Case 4".

<table>
<thead>
<tr>
<th>Case</th>
<th>Points</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.</td>
<td>15.</td>
<td>One scarf tip sheared loose, or evidence of the stock breaking due to burning.</td>
</tr>
<tr>
<td>6.</td>
<td>18.</td>
<td>No evidence of the weld shearing, or the stock breaking due to overheating.</td>
</tr>
</tbody>
</table>

4. Total the scores.
5. Time corrections. Assign corrections as before.
6. Retrials. Assign corrections as before.
7. Under size at the weld. Assign a correction of minus two points if the stock is drawn under size.
9. Total the corrections.
10. Calculate the final score.
Informational Test -- Scoring keys.

Contract I - Form A.

Completion

1. -----------
   a. Cast or pig iron.
   b. Steel.
   c. Wrought iron.

2. Hot iron must not come in contact with green coal.

3. From in front of the shoulder.


5. Clinkers.


7. Yellow.

8. Cast iron.


11. Finishing.

12. 5000 years.

Matching

7  A.
6  B.
5  C.
3  D.
8  E.
5  F.
1  G.
7  H.
2  I.
5  J.
8  K.
4  L.
5  M.

Processes

1. The parentheses should be filled in the following order.
   (b), (e), (d), (a), (c).

2. 3/4"  

3.  -----------

Recognition

1. Cross peen hammer.

2. Hollow bit tongs.

3. Hot punch.

4. Shovel.

5. Hot hardy.
1. Fire building and maintaining.
2. Drawing.
4. Bending.
5. Heading.
6. Punching and splitting.
7. Cutting stock.

**Form B.**

<table>
<thead>
<tr>
<th>Completion</th>
<th>Matching</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Wrought iron or mild steel---forged.</td>
<td>2</td>
</tr>
<tr>
<td>2. Sharp shoulders---drawing.</td>
<td>4</td>
</tr>
<tr>
<td>3. Will not form coke.</td>
<td>7</td>
</tr>
<tr>
<td>4. Finishing round stock.</td>
<td>5</td>
</tr>
<tr>
<td>5. Finishing flat stock.</td>
<td>6</td>
</tr>
<tr>
<td>6. Cutting and drawing when using the peen of the hammer.</td>
<td>4</td>
</tr>
<tr>
<td>7. Coke</td>
<td>1</td>
</tr>
<tr>
<td>8. Carbon</td>
<td>3</td>
</tr>
<tr>
<td>9. Leverage</td>
<td>4</td>
</tr>
<tr>
<td>10. Tool steel</td>
<td>6</td>
</tr>
<tr>
<td>11. Drawing</td>
<td>4</td>
</tr>
<tr>
<td>12. Oxidizing</td>
<td>3</td>
</tr>
</tbody>
</table>
Form B. (Continued)

<table>
<thead>
<tr>
<th>Processes</th>
<th>Recognition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The parentheses should be filled in the following order.</td>
<td>1. Rake.</td>
</tr>
<tr>
<td>(e), (c), (a), (d), (b).</td>
<td>2. Flatter.</td>
</tr>
<tr>
<td>2. 8-5/8 inches.</td>
<td>3. Hot cutter.</td>
</tr>
<tr>
<td>3. ---------------</td>
<td>4. Poker.</td>
</tr>
<tr>
<td>1. Building and maintaining a fire</td>
<td>5. Cold hardie.</td>
</tr>
<tr>
<td>3. Drawing.</td>
<td>7. Flat-jawed tongs.</td>
</tr>
<tr>
<td>5. Heading.</td>
<td>9. Link tongs.</td>
</tr>
<tr>
<td>7. Upsetting.</td>
<td></td>
</tr>
<tr>
<td>8. Shouldering.</td>
<td></td>
</tr>
</tbody>
</table>
### Completion Matching

1.  
   a. Hammering lightly.  
   b. Refine the grain.  

2.  
   a. The stock may be drawn to size.  
   b. Squeeze out the slag.  

3. They may damage the threading tools.  

4. Tool steel, mild steel, or wrought iron.  

5.  
   1. Forge.  
   2. Acetylene.  
   3. Electric.  
   4. Thermit.  

6.  
   1. Pig or cast iron.  
   2. Slag.  

7.  
   1. Flat.  
   2. Round.  
   3. Square.  
   4. Hexagonal.  
   5. Octagonal.  
   6. Angle iron.  
   7. T-beam.  
   8. I-beam.  
   9. Channel iron.  
   10. Sheet.  
   11. Pipe.  
   12. Tubing.  

### Processes Recall

1. Reducing.  

2. Slowly.  


4. Against.
4. Welding, or heading and punching.
5. Shouldering.
6. Heading and riveting.
7. Filing.
8. Riveting.
10. Finishing.

3. ---------------
1. Cutting stock.
2. Fire building and maintaining.
4. Drawing.
5. Drilling.
6. Welding.
7. Finishing.
8. Riveting.

Form B.

Completion | Matching
---|---
1. Pressing too hard on the file. | 7 A.
2. Finishing. | 10 B.
3. Driving it out with a drift key. | 11 C.
4. Smaller. | 6 E.
5. As close as possible and yet not touch the wheel. | 5 F.
6. ---------------
1. Ornamentation. | 3 H.
2. Preservation. | 4 I.
7. The thickness of the stock. | 6 J.
8. ---------------
1. Iron ore. | 1 K.
2. Limestone. | 8 L.
3. Flux. |
Form B (Continued)

Processes

1. 58-1/2 inches.

2. 
   1. Fire building and maintaining.
   2. Cutting stock.
   3. Drawing.
   4. Punching.
   5. Welding.
   6. Heading.
   7. Shouldering.
   8. Bending.

3. 
   1. Cutting stock.
   2. Building and maintaining a fire.
   3. Drawing.
   4. Twisting.
   5. Riveting.
   6. Welding.
   7. Bending.

Recall

1. Slowly.

2. Down.

3. Tap wrench.

4. Slowly.

5. Carbon.

6. Fibrous.

7. Hardened or hot.

8. Dressed.
Determining the Contract Grades.

Performance Test.
1. Total the scores earned by the students for the various parts of a test.
2. Distribute the total scores.
3. Divide the scores into groups as before. The five divisions should be made at natural breaks in the distribution.
4. Assign the following grade-point values.

<table>
<thead>
<tr>
<th>Group</th>
<th>Grade-points</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. (Highest)</td>
<td>4</td>
</tr>
<tr>
<td>2.</td>
<td>3</td>
</tr>
<tr>
<td>3.</td>
<td>2</td>
</tr>
<tr>
<td>4.</td>
<td>1</td>
</tr>
<tr>
<td>5.</td>
<td>0</td>
</tr>
</tbody>
</table>

Informational Test
1. Total the scores earned by each student for a test.
2. Distribute the scores.
3. Divide the total scores into groups and assign grade-point values as explained for the performance tests.

Shop Work
1. Total the scores earned by each student.
2. Distribute the scores.
3. Divide the scores into groups as before.
4. Assign grade-point values as shown below.
<table>
<thead>
<tr>
<th>Group</th>
<th>Grade-point</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. (Highest)</td>
<td>8</td>
</tr>
<tr>
<td>2.</td>
<td>6</td>
</tr>
<tr>
<td>3.</td>
<td>4</td>
</tr>
<tr>
<td>4.</td>
<td>2</td>
</tr>
<tr>
<td>5.</td>
<td>0</td>
</tr>
</tbody>
</table>

**Final Grade**

Grades for the contracts are determined on the basis of grade-points. Total the grade points earned by each student for the shop work, the performance test, and the informational test. Distribute the totals and divide them into groups. Assign grades according to the following table.

<table>
<thead>
<tr>
<th>Group</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. (Highest)</td>
<td>A</td>
</tr>
<tr>
<td>2.</td>
<td>B</td>
</tr>
<tr>
<td>3.</td>
<td>C</td>
</tr>
<tr>
<td>4.</td>
<td>D</td>
</tr>
<tr>
<td>5.</td>
<td>F (See the following)</td>
</tr>
</tbody>
</table>

The instructor should, of course, use his judgment in assigning a failing grade. A student who has done his best should never be given a failing grade, except in case it may be necessary when a student may need to repeat the work in order to develop the necessary foundation for advance work in the chosen field of shop activity.
APPENDIX G.

TESTS
PERFORMANCE TEST
Performance Tests.

(General directions for students)

The performance tests consist of four parts for each contract. The projects in these tests are similar to the ones done as daily shop work. At times it will be necessary to supplement the directions given with the tests, with information that has been received while doing your shop work.

Stock will be issued for each part by your instructor. The test for each contract will require parts of four days. Turn in your test project as soon as it is completed. The projects requiring welding should be turned in while hot. The stock will be issued for only one part of the test at a time. This stock will be issued while the class is assembled. The tools that are needed for the test have been placed on the forges. The coal and coke have been evenly distributed.

The finished tests will be carefully graded by measuring each dimension. A time record will be kept from the time the stock is issued. If the stock should be ruined an additional piece may be secured, but your score will be reduced by each successive trial, and the total time will be counted from the time the first stock was issued. The work on each part of the tests must be completed in not more than one hour and fifteen minutes.
Grading rules will depend upon the particular project or test under consideration, though accuracy and time will always be considered. Your instructor will explain the manner of grading each part of the tests before you make them. In all cases work as rapidly as you can and yet do the best quality of work.

Warning! Do not waste any time for you will need all that is allowed.
CONTRACT I

Part A
Stock: \( \frac{1}{2} \text{Rd-4L} \)

Working directions:

1. Draw \( \frac{1}{2} \) round stock to \( \frac{3}{8} \) square.
2. Draw square point \( 1'' \) long on one end.
3. Leave \( 2'' \) of stock square, and shoulder and draw the remaining stock to \( \frac{3}{8} \) round.
4. Cut off the surplus stock and forge a round point \( \frac{3}{4} \) long.
5. Check to see that the length over all is \( 5\frac{3}{4}'' \).
6. Check to see that the finished work is straight.

Turn in the test for grading.

Drawn by Roy Nelson RUHS 4/25/33
Part B

Stock: \( \frac{1}{2} R \ 4^\prime \ L \)

Working directions:
1. Lay out \( \frac{1}{4} \) from one end.
2. Shoulder and draw this to \( \frac{1}{4} \) round.
3. Allow for a \( \frac{1}{2} \) square point and cut off the surplus stock.
4. Lay-out \( \frac{1}{2} \) for the head and cut the nail off from the stock.
5. Forge the head to size.
6. Turn in for grading.

Drawn by Roy Nelson  RHMS. April 24, 1933
CONTRACT I

Part C
Stock: 16R 7¼" L.

Working directions:
1. Square up one end of the stock.
2. Lay-out 4 15/16" from this end.
3. Bend this stock to right angles.
4. Bend the eye.
5. Cut the stock so that the eye-pin is 4" long over all.
6. Turn your work in for grading.

Drawn by Roy Nelson AUHS. May 1, 1933.
**CONTRACT I**

**Part D**

Stock: $\frac{3}{8}$ square - 4" L.

Working directions:

1. Upset the end of the stock to $\frac{5}{8}$ square.

2. Lay-out $\frac{3}{4}$ from the end and shoulder to $\frac{5}{6}$ thickness.

3. Shape the end round.

4. Punch a $\frac{1}{2}$" hole in the center.

5. Turn in for grading.

*Drawn by Roy Nelson P.U.H.S. April 24, 1933*
CONTRACT II

Performance Test

Part A. Eye-pin
Stock 5/16 Rd. - 8"L.

Working directions:
1. Lay out as shown by the following sketch.

2. Up-set the stock a little about 2" from the end so that the scarf may be closed without drawing the stock under size.

3. Draw the scarf.
4. Bend the eye
5. Weld the eye
6. Finish and turn in for grading

By Thomas Brown
CONTRACT II

Performance Test

Part B
Stock: \( \frac{1}{2} \)" square. 10" Long

Working directions:

1. Up-set each end as required for forming scarfs.
2. Form a scarf on each end.
3. Cut the stock in two in the middle.
4. Join the pieces by welding.
5. Lay-out and twist a 2\( \frac{1}{2} \)" section near one end.
   Twist the stock one complete turn.
6. Turn in for grading.
Part C
Ring

Stock: \( \frac{3}{4} \) R. 9 L
Working directions.
1. Bend the stock as directed for making a small ring.
2. Form scarfs as for a chain link.
3. Close the scarfs.
4. Weld the ring.
5. Shape and finish the ring.
6. Turn in for grading.
CONTRACT II

Performance Test

Part D (Chain link)

Stock: \( \frac{3}{8} R - 6^\prime L \)

1. Bend the stock into the proper "U" shape.
2. Form the scarfs.
3. Bend the scarfed ends so that they lap.
4. Weld the link.
5. Turn in for grading.
INFORMATIONAL TESTS
Date_________________ Name_____________________________________

Directions: The following questions are to be answered as the question indicates. Place your answers in the spaces provided for this purpose. (Each correct response earns two points towards your score.)

1. Name three principal classes of iron.
   1. __________________ 2. __________________ 3. __________________

2. The front of a forge fire should not be banked with green coal because ____________________________________________

3. A smith's helper should strike from ____________________________

4. The fullers are used for ______________________________________ and ________________________________________

5. The impurities from coal and iron scales fuse together in the bottom of the fire pot forming ____________________________

6. Blacksmithing coal which has been dampened with water is known as ____________________________

7. When wrought iron or mild steel is at the proper temperature for forging its color is ____________________________

8. The principal class of iron which is brittle, has a crystalline structure, and cannot be forged is ____________________________

9. Iron is obtained from the earth in the form of ____________________________

10. The type of fire which will destroy the oxidized surface on iron is called a (or an) ____________________________ fire.

11. In forging, a dark red heat is used for ____________________________

12. Iron has been used by man for about ____________________________ years.
Contract I. RECOGNITION (FORM A) Informational Test.

Date_________________________ Name________________________.

Directions: Several blacksmithing tools have been placed before you. Each tool is numbered. Place the names of the tools beside the corresponding numbers which appear on this sheet. (Each correct response earns two points toward your score.)

1. __________________________
2. __________________________
3. __________________________
4. __________________________
5. __________________________
6. __________________________
7. __________________________
8. __________________________
9. __________________________
10. __________________________
Contract I.  PROCESSES (FORM A) Informational Test.

Date_________________________ Name_____________________________________

Directions: The following problems are typical of those commonly encountered in the shop. Solve them as the directions indicate. (The first two are rated at five points each. The last will be scored by allowing one point for each correct response.)

1. The steps in making an eye-bend. They are now out of order. Indicate the correct order by placing the letters "a", "b", "c", etc. in the parentheses.

( ) Bend the stock for the eye so that it is at right angles to the rest of the stock.
( ) Straighten the eye on the horn or edge of the anvil.
( ) Close the eye on the edge of the anvil.
( ) Calculate the length of stock needed for the eye.
( ) Bend the end of the stock to the proper size on the horn of the anvil.

2. Calculate the length of stock required for the following tenon... (Show your work.)

3. The operations involved in making the wrench and rivet are:

1.___________________________
2.___________________________
3.___________________________
4.___________________________
5.___________________________
6.___________________________
7.___________________________
**Contract I. MATCHING FORM A) Informational Test.**

**Date** ___________________________ **Name** ___________________________

Directions: The following two columns contain definitely related statements. Place the number of the statements in Column I in front of the statements in Column II with which they match. Some of the statements in Column I match with more than one of the statements in Column II. *(Each correct response earns one point towards your score.)*

<table>
<thead>
<tr>
<th>Column I</th>
<th>Column II</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The class of iron used the most in industry.</td>
<td>A. Angle.</td>
</tr>
<tr>
<td>2. Cause for a point to split while being forged.</td>
<td>B. Upsetting.</td>
</tr>
<tr>
<td>4. The black surface on iron is due to ---</td>
<td>D. Expands.</td>
</tr>
<tr>
<td>5. Parts of the anvil.</td>
<td>E. Plan.</td>
</tr>
<tr>
<td>6. That operation which increases the cross-sectional area of the stock.</td>
<td>F. Pritchel hole.</td>
</tr>
<tr>
<td></td>
<td>I. Stock has been burned.</td>
</tr>
<tr>
<td></td>
<td>J. Horn.</td>
</tr>
<tr>
<td></td>
<td>K. Tuyere.</td>
</tr>
<tr>
<td></td>
<td>L. Oxidation.</td>
</tr>
<tr>
<td></td>
<td>M. Face.</td>
</tr>
</tbody>
</table>
Contract I. COMPLETION (FORM B) Informational Test.

Date __________________________ Name ________________________________

Directions: The following questions are to be answered as the question indicates. Place your answers in the spaces provided for this purpose. (Each correct response earns two points towards your score.)

1. The cold shear should be used only for cutting _______ which has not been _______.

2. The set hammer is used to form _______ and to _______ between narrow spaces.

3. Hard coal is not suited for forging because it _______.

4. The swages are used for _______.

5. The flatter is used for _______.

6. The base of the horn on an anvil is used for _______.

7. Green coal banked around the sides of the fire is transformed by heat into _______.

8. All commercial forms of iron contain iron alloyed with some _______.

9. The hammer blow used for forging points is the _______ blow.

10. Hardies, punches, chisels, hammers, etc., should be made of a high grade of _______.

11. That operation which reduces the cross-sectional area of stock by hammering or pressure is called _______.

12. The type of fire which causes the iron to become rough, pitted, or burned is called a (or an) _______ fire.
Contract I.  PROCESSES (FORM B) Informational Test.

Date________________________Name________________________

Directions: The following problems are typical of those commonly encountered in the forge shop. Solve them as the directions indicate. (The first two are rated at five points each. The last will be scored by allowing one point for each correct response.)

1. The steps in forging a 1/2" round tenon on 1" round stock. They are now out of order. Indicate the correct order by placing the letters "a", "b", "c", etc., in the parentheses.
   ( ) Finish in the swages.
   ( ) Use a flatter to smooth the 1/2" square stock.
   ( ) Use the top and bottom fullers to form the shoulders from two sides at a time.
   ( ) Use a hand hammer to draw the 1/2" square to 1/2" round.
   ( ) Use the fuller to roughly draw the tenon to 1/2" square.

2. Calculate the length of stock required for making the butt-joint ring. (Show your work).

3. The operations involved in making the hinge and nail are:

   1. ______________________
   2. ______________________
   3. ______________________
   4. ______________________
   5. ______________________
   6. ______________________
   7. ______________________
Contract I. MATCHING (FORM B) Informational Test.

Date ____________________________ Name ____________________________

Directions: The following two columns contain definitely related statements. Place the number of the statements in Column I in front of the statements in Column II with which they match. Some of the statements in Column I match with more than one of the statements in Column II. (Each correct response earns one point towards your score.)

<table>
<thead>
<tr>
<th>Column I</th>
<th>Column II</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. A fire should be banked with---</td>
<td>__ A. Slag seam in the stock.</td>
</tr>
<tr>
<td>2. Causes for a point to split while being forged.</td>
<td>__ B. Tool hole.</td>
</tr>
<tr>
<td>3. A tool used for cutting iron.</td>
<td>__ C. Fire pot.</td>
</tr>
<tr>
<td>4. Parts of the anvil.</td>
<td>__ D. Shouldering.</td>
</tr>
<tr>
<td>5. That operation which reduces the cross-sectional area of stock at a</td>
<td>__ E. Leverage.</td>
</tr>
<tr>
<td>given point.</td>
<td>__ F. Base of the horn.</td>
</tr>
<tr>
<td>7. Parts of the forge.</td>
<td>__ H. Hardie.</td>
</tr>
<tr>
<td></td>
<td>__ I. Round and square edges.</td>
</tr>
<tr>
<td></td>
<td>__ J. Edge-to-edge.</td>
</tr>
<tr>
<td></td>
<td>__ K. Base.</td>
</tr>
<tr>
<td></td>
<td>__ L. Blower.</td>
</tr>
<tr>
<td></td>
<td>__ M. Hot cutter.</td>
</tr>
</tbody>
</table>
Contract I.  RECOGNITION (FORM B) Informational Test.

Date __________________________ Name __________________________

Directions: Several blacksmithing tools have been placed before you. Each tool is numbered. Place the names of the tools beside the corresponding numbers which appear on this sheet. (Each correct response earns two points towards your score.)

1. 
2. 
3. 
4. 
5. 
6. 
7. 
8. 
9. 
10. 
Contract II.  COMPLETION (FORM A) Informational Tests.

Date________________________ Name_________________________________

Directions: The following questions are to be answered as the question indicates. Place your answers in the spaces provided for this purpose. (Each correct response earns two points towards your score.)

1. Welded sections should be finished by ________________ to ________________ the grain.

2. Stock should be up-set and scarf ed for welding so that _________________.

3. Heavy scales should be removed from stock which is to be threaded because _________________.

4. The cleft weld is used for joining _________________.

5. Four common methods of welding:
   1. ________________  3. ________________
   2. ________________  4. ________________

6. The two materials which are drawn from a blast furnace during the smelting process are:
   1. ________________  2. ________________

7. Wrought iron and steel may be obtained in the following shapes.
   1. ________________  6. ________________
   2. ________________  7. ________________
   3. ________________  8. ________________
   4. ________________  9. ________________
   5. ________________  10. ________________
Contract II. RECALL (FORM A) Informational Test.

Date_____________________________Name_____________________________

Directions: The following statements have the key word or words omitted. Write these in the lines where they have been omitted. (Each correct response earns two points towards your score.)

1. The type of fire which is used for welding is known as a (or an) ____________________ fire.

2. Welded jobs should be cooled ____________________.

3. The material most commonly present in welding fluxes is ____________________.

4. Cutting tools should be held so that the stone cuts ____________________the cutting edge of the tool.

5. A weld is a ____________________ union between two or more pieces of like metal.

6. A cutting compound is used when drilling iron if the drill cuts a ____________________.

7. The universal process for the production of wrought iron is known as ____________________.

8. When grinding tempered tools one must be careful to avoid ____________________the tool.
Contract II.  PROCESSES (FORM A) Informational Test.

Date_____________________ Name__________________________

Directions: The following problems are typical of those commonly encountered in the forge shop. Solve them as the directions indicate. (The first one is rated at five points. The others will be scored by allowing one point for each correct response.)

1. Ring. The length of stock that would be needed is: (Show your work.)

   ![Diagram of a ring with dimensions 24" long and 1" square]

2. Soldering copper. List the operations involved.

   ![Diagram of soldering tools]

   1. 
   2. 
   3. 
   4. 
   5. 
   6. 
   7. 
   8. ____________________________

   Copper
3. Bracket. List the operations involved:

1. 
2. 
3. 
4. 
5. 
6. 
7. 
8. 
Contract II.  MATCHING (FORM A) Informational Test.

Date ____________________ Name _____________________

Directions: The following two columns contain definitely related statements. Place the number of the statements in Column I in front of the statements in Column II with which they match. Some of the statements in Column I match with more than one of the statements in Column II. (Each correct response earns one point towards your score.)

<table>
<thead>
<tr>
<th>Column I.</th>
<th>Column II.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. A fire for welding must free from----</td>
<td>A. By a chuck.</td>
</tr>
<tr>
<td>2. Fluxes aid in welding by---</td>
<td>B. Grabbing as it passes through the stock.</td>
</tr>
<tr>
<td>3. A tool used for cutting internal threads.</td>
<td>C. Correct heat.</td>
</tr>
<tr>
<td>4. A fire for welding must have----</td>
<td>D. Not sharpened correctly.</td>
</tr>
<tr>
<td>5. A tool used for cutting external threads.</td>
<td>E. By the drill spindle.</td>
</tr>
<tr>
<td>6. Stock is usually twisted for the purpose of----</td>
<td>F. Lowering the melting point of the exide.</td>
</tr>
<tr>
<td>7. Steps in the puddling process.</td>
<td>G. Deep bed of coke under the iron.</td>
</tr>
<tr>
<td>8. When drilling, straight shank drills are held----</td>
<td>H. Clinkers.</td>
</tr>
<tr>
<td>9. Conditions which may cause a drill to break.</td>
<td>I. Prevent further oxidation.</td>
</tr>
<tr>
<td>10. Types of ornamental iron finish.</td>
<td>J. Die.</td>
</tr>
<tr>
<td>11. When drilling, taper shank drills are held--</td>
<td>K. Ornamentation.</td>
</tr>
<tr>
<td></td>
<td>M. Flat black.</td>
</tr>
<tr>
<td></td>
<td>N. Correctly shaped scarf.</td>
</tr>
<tr>
<td></td>
<td>O. Coke over the iron.</td>
</tr>
<tr>
<td></td>
<td>P. Forming a fusible slag.</td>
</tr>
<tr>
<td></td>
<td>Q. Tap.</td>
</tr>
<tr>
<td></td>
<td>R. Boiling.</td>
</tr>
</tbody>
</table>
Contract II. COMPLETION (FORM B) Informational Test.

Date. ___________________ Name___________________________

Directions: The following questions are to be answered as the question indicates. Place your answers in the spaces provided for this purpose. (Each correct response earns two points towards your score.)

1. Pins are formed on a file by_______________________________.

2. Draw-filing is a process used for_______________________________.

3. Remove a taper shank drill from the drill press by_______________.

4. The size of a drilled hole which is to be threaded must be___________________ than the thread size.

5. The rest on an emery grinder should be set_______________________.

6. The purposes for painting ornamental iron are_________________ and___________________.

7. An extra allowance of stock should be made for welding jobs which is equal to___________________________.

8. The three materials which are charged into a blast furnace for the production of pig iron are:

1. ____________________________

2. ____________________________

3. ____________________________
Directions: The following statements have the key word or words omitted. Write these in the lines where they have been omitted. (Each correct response earns two points towards your score.)

1. The rate at which a welding heat is taken is _________.

2. While taking the final heat for welding the scarfs should be faced _________.

3. The tool used for operating a tap is called a _________.

4. Jobs which are to be threaded should be cooled ________ to soften the iron.

5. The weldability of iron and steel is determined by the per cent of ________ in the iron.

6. wrought iron has a ________ structure.

7. A file should not be used on ________ steel.

8. Emery stones which do not run smoothly should be _________.

Date ___________________ Name _______________________

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Date ___________________________ Name ___________________________

Directions: The following problems are typical of those commonly encountered in the forge shop. Solve them as the directions indicate. (The first one is rated at five points. The others will be scored by allowing one point for each correct response.)

1. **Band.** The length of stock that would be needed is: (Show your work.)

   ![Diagram of Band](image)

   Stock: \( \frac{1}{2} \times \frac{1}{2} \)

2. **Swivel-eye.** List the operations involved:

   1. ___________________________
   2. ___________________________
   3. ___________________________
   4. ___________________________
   5. ___________________________
   6. ___________________________
   7. ___________________________
   8. ___________________________
3. Candelabrum. List the operations involved:

1. 
2. 
3. 
4. 
5. 
6. 
7. 
8. 
**Contract II MATCHING (FORM B) Informational Test.**

**Date_________________________**  
**Name__________________________________________________________**

**Directions:** The following two columns contain definitely related statements. Place the number of the statements in Column I in front of the statements in Column II with which they match. Some of the statements in Column I match with more than one of the statements in Column II.  
(Each correct response earns one point towards your score.)

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<tr>
<td>1. Cold manipulation of iron causes it to become--</td>
<td>A. Hammering or pressure.</td>
</tr>
<tr>
<td>2. Puddling is a process of----</td>
<td>B. Stock not set up correctly.</td>
</tr>
<tr>
<td>3. Iron which is to be painted must be free from-----</td>
<td>C. Broken.</td>
</tr>
<tr>
<td>4. A fire for welding must be free from-----</td>
<td>D. Feeding too rapidly.</td>
</tr>
<tr>
<td>5. The mixture which is added to cast iron during the puddling process is----</td>
<td>E. Mixing.</td>
</tr>
<tr>
<td>6. The steps in the puddling process.</td>
<td>F. Oxidizing.</td>
</tr>
<tr>
<td>8. Operating a drill at too high a speed may cause it to-----</td>
<td>H. Oil.</td>
</tr>
<tr>
<td>10. Conditions which may cause a drill to break.</td>
<td>J. Balling.</td>
</tr>
<tr>
<td>11. Operating a drill at to low a speed may cause it to-----</td>
<td>K. Soft.</td>
</tr>
<tr>
<td></td>
<td>L. Burned.</td>
</tr>
<tr>
<td></td>
<td>M. Bronzed.</td>
</tr>
<tr>
<td></td>
<td>N. Suitable fire.</td>
</tr>
<tr>
<td></td>
<td>O. Sulphur.</td>
</tr>
<tr>
<td></td>
<td>P. More dense.</td>
</tr>
<tr>
<td></td>
<td>Q. Moisture.</td>
</tr>
<tr>
<td></td>
<td>R. Decarbonization.</td>
</tr>
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