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A PLAN FOR INTEGRATING A "GENERAL SHOP" PROGRAM

Contemporary society depends for its well being on mechanical environment to an almost unbelievable extent. A large portion of earnings is expended for mechanical merchandise, and mechanical devices are now in the hands of every individual. Joys and successes of daily activity have become increasingly dependent on ability to fabricate and to operate such devices.

Education for mechanical dexterity should be as universal and fundamental as that in the three "R's". For the latter the educational curriculum requires definite courses of all individuals, yet in the mechanical field offers only a poorly regulated course which, too often, is merely an elective pursued by a small number.
Industrial arts education should be organized to develop a mechanical thought habit as extensive as the word thought habit is in the abstract field. The general shop plan of instruction is the most adaptable but, under conditions of the one-hour shop period and large classes, is frequently too indefinite. A beginning shop course is needed that necessitates a more definite attainment and that will not be regarded as a dumping ground for any portion of the school day.

This thesis illustrates the use of the association principle of learning. It attempts to point out similarities in instructional processes of the general shop, and to integrate into such instruction topics of common interest to members of the entire class.

The development of the program is based on an analysis of the unit shop standards of attainment, as compiled by a committee of the American Vocational Association. These standards were reorganized according to the process of fabrication rather than to the trade divisions of industry. The processes were titled: first, forming to shape (including the operations of cutting, bending, and molding); second, forming the joint area; and third, fastening the joint area.

These processes were so elemental that most of the direct group instruction can be done on the basis
of interest to the entire class. The individual instruction may be indirect through the use of instruction sheets and numerous types of visual aids. Examples of topics for the common interest of the class are; The Characteristics of Cutting Tools; The Similarities of Iron and Wood--their structure and the processes used in their fabrication. Additional topics for class interest are given in the Appendix.

Another feature of the program is the development of individual, easily-scored forms to aid in keeping an adequate record of student progress and to encourage each student to strive for maximum accomplishment.
A PLAN FOR INTEGRATING A "GENERAL SHOP" PROGRAM

by

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A PLAN FOR INTEGRATING A "GENERAL SHOP" PROGRAM

CHAPTER I
INTRODUCTION

STATEMENT OF THE PROBLEM

Present society exists in an industrial world. Every individual, regardless of sex or age, is constantly fabricating or manipulating industrial materials and products. The problem is to educate all people that they may know the language, so to speak, and the human efforts necessarily involved in industrial processes. In industrial arts, a general shop course is probably the best means by which to accomplish this.

It is necessary to think in terms of the amount of education needed by the individual to enable him to cope successfully with modern industrial environment. Progress should be based on achievement. Students should not be merely "floated" along for four years. They should be impressed with responsibility for attainment and not be contented with "trial-and-don't-like" or "trial-and-failure" habits. Industrial arts education should become a major subject comparable to English and covering an adequate period of time dependent upon individual
progress. It will, of course, be necessary to procure public recognition of this view.

The general shop is not the result of a temporary economy measure, nor is it a passing fad. It has been promoted by leading educators as the proper course to introduce the field of industrial arts, but this view has not yet been accepted by industrial arts teachers as a group. It therefore becomes imperative to pay particular attention to the organization of the subject matter of this course.

Unit courses in industrial arts, especially in lower division work, are too narrow and disconnected to develop a consciousness of mechanical environment. One often hears, "Oh, yes, I had a course in that once, but it didn't mean much to me, and I've forgotten it." Learning is a matter of association and repetition, and to be beneficial must be a continued process.

Segregation of this field of industrial arts into a few trade divisions, to be pursued in disconnected units for try-out, exploratory, or other purposes, prevents what should be an integrated appreciation. No try-out courses are given in the three "R's".
As in the teaching of reading, so also in the teaching of industrial education, the early stages should not be regarded as a training for livelihood. The course should enrich the appreciation of life and assist in adaptation to the mechanical environment. General shop should be continued until the student has attained a broad appreciation of the industrial field, and not until the junior or senior year should the program provide for specialized training of a vocational or semi-vocational nature.

IMPORTANCE OF THE PROBLEM

There is a popular vagueness concerning the scientific and mechanical world. Mechanical tools of daily life are here to stay, and we must devise school training to integrate the natural sciences with present-day mechanical equipment. Those in industrial arts education must provide a course of such graduated content that it will leave the student still curious at the end of his school training.

When the importance of this problem is recognized, industrial arts teachers will avail themselves of further training in adolescent psychology so that they may maintain student curiosity and
thus establish a course of study worthy of universal acceptance.

The beginning curriculum in industrial arts education will then result in a standardization of the general shop. Advanced courses will emphasize the vocational desires and hobbies of individuals, as well as the interests of the local community.
CHAPTER II
DEVELOPMENT OF THE PROGRAM

DIFFICULTIES TO BE OVERCOME

For several years the writer has taught departmentalized shop work in woodwork and auto mechanics. The handicaps and limitations in these two subjects caused him to become interested in evolving a wider range of facilities to meet the average shop problem. The first step was the establishment of a prerequisite of general metal work to the course in auto mechanics. This general metal work had in turn the prerequisite of elementary woodwork. Later the two courses were combined so as to introduce a special unit of treatment that will be described presently. Today a more complete general course is offered which has been made prerequisite to all other shop courses.

Among the early problems encountered were those of managing the large growth in class size and of creating interest. Unfortunately the enforcement of the compulsory attendance law creates in many instances a mental barrier between the boy and his school work, as a result
of which the boy enrolls for shop work as an easy way out. From the start, therefore, the teacher's problem is one of salesmanship.

Some shop students really want to learn and are willing to work. Other students come to school only because they are sent by their parents and aim merely to "get by". Still others are sent by the probation officer. This combination may produce a problem of discipline. The best method for avoidance of discipline problems is the creation of an atmosphere of purposeful work. In large groups, this work cannot be left to unguided or even to guided boy interests. The units of learning must arouse curiosity, and, to a certain extent, should be new to the learner and of a nature unlikely to be acquired in his own backyard. School shops cannot be justified merely on the ground of activity for activity's sake. The teacher's responsibility is to show the student that a school shop affords opportunity for things not to be gained elsewhere and offers a rich accumulation of data and selected experiences which his elders have spent a lifetime in acquiring. A new student's interest should be stimulated by the
type of work he sees going on about him. He must then be made to realize that there are progressive "hurdles" to be taken if he is to gain and maintain a worthwhile standing in shop work.

The curriculum and the student do not offer the only obstacles to the success of a general shop program. The personality and preparation of the teacher may also spell success or failure. An able teacher and leader of boys will accomplish results almost automatically. A teacher of only ordinary ability can nevertheless be an outstanding success provided he is well-trained in psychology and pedagogy, is a conscientious worker, and is well-grounded in the philosophy of "motivation of student work by student interest"; and provided further that the keynote in the Smith-Hughes philosophy of teaching can be realized: namely, that he does not have to work with too large a class. However, a teacher who himself is a poor student and who is weak in the understanding of boys is likely to establish an inflexible course in shop work and so to create an attitude among the boys of just "battling" through for credit.

NECESSARY PROCEDURES
With large classes, the instructional aids previously used were found inadequate. Records of attainment were cumbersome; project work was too advanced; and the repetition of work was insufficient to develop either skill or thoroughness of understanding. Thus certain changes in the procedures became necessary.

For example: First, a large workable supply of instructional aids, including samples, reference charts, illustrations, and instruction sheets, were provided.

Second, instruction sheets were made more concise. It was found better to omit a point or two of instruction than to have too much detail. Instruction sheets with too elaborate statements of objectives are deadly dull to the average boy.

Third, information was more explicitly given. A few fundamental instruction sheets were carefully prepared so that they could be used for many projects and also for later reference. (Instruction Sheets Nos. 30, 37, and 39, Appendix C)

In project work, instruction involving much repetition and drill may best be given by merely outlining or listing points of instruction. The
boy can be taught to find his own references and source of information. Instruction Sheet No. 42, Appendix C, furnishes an example. It will be noted that, in the examples referred to, one manipulative process definitely integrates all four instruction sheets: the "square step", fundamental to reducing or tapering work in forging.

Fourth, a thorough analysis was made to determine what units are most elementary, basic, or fundamental. This study permitted a limitation of the course, and thus made it possible to avoid a common fault of the general shop program, namely that of a spread in the offerings far too wide for purposeful attainment. Through thoroughness of accomplishment, boys learn to enjoy their work.

Fifth, a means of checking and testing was devised that is simple to administer and quick to record.

Sixth, since the time available for a shop period is only one hour, all physical equipment was made readily accessible. Tools and materials were so arranged and labeled that the boys quickly
acquired a "position habit" and also learned shop nomenclature.

CONTENT OF BEGINNING COURSE

Great credit is due the committee of the American Vocational Association for its work in preparing standards of attainment in industrial arts. With these data at hand, the first task for the author was to ascertain what should be selected for a beginning shop course. Courses pertaining to service and technical trades, such as auto mechanics, were eliminated. Technical and service subjects, such as electricity, auto mechanics, farm mechanics, etc., were reserved for inclusion in more advanced courses in which the emphasis is on the technical, rather than on the manipulative phases of the subject. For example, instruction in electricity should be centered on the laws of electrical phenomena and the associated mathematical calculations, and not on the methods of sawing, filing, soldering, or other processes necessary to the fabrication of the electrical project under consideration.

The first shop work offered in a well-
integrated course will give emphasis to skills of operation and to information about materials of fabrication. Later, after the student has attained success on this elementary level, (from a few months for more capable students to two years for less capable ones), courses in advanced shop work will provide him with the necessary specialization.

OBJECTIVES OF THE COURSE

The objectives of the course are listed herewith:

I From the student's point of view:

A. For all shop students-
   1. Better understanding of occupations.
   2. Increased appreciation of a craftsman's work.
   3. Development of a desirable consumer's appreciation of labor and material.

B. For mechanically adept students-
   1. Provision of a basis for later vocational training.
   2. Provision of a background for hobbies and recreational life.

II From the professional teaching point of
1. Establishment of a closer correlation between the parts of the entire mechanical field.

2. Provision for a more intensive use of the association principle of learning.

3. Integration of the work so as to develop a mechanical thought habit comparable to the word thought habit in the abstract field.

4. Provision of the necessary educational environment within the shop to develop an appreciation of the mechanic arts.

5. Development of clerical aids for records and class management.

6. Allowance for free and rapid individual progress when periods are short and classes large.

7. Promotion of the habit of the scientific mode of thinking and experimentation.


9. Contribution to the establishment of
industrial arts education on a sound educational basis.

A careful analysis was made to determine what constitutes the major part of shop work; also to learn wherein the student needs the most help by direct instruction and wherein he can be aided by instructing him to help himself. In this study, no attempt was made to duplicate any work already available. By the nature of the work, originality was limited to the rearrangement and compilation of certain elementary material for a better adaptation to existing conditions.

RECLASSIFICATION OF UNITS

A departmentalized general shop utilizes the many-ring circus idea, accompanied by the problems of how to get the groups to change "rings" at the correct time, and how to retain students in the proper groups. Therefore the attainment units of the unit shop as set up by the American Vocational Association were pooled and reclassified according to an analysis of the processes of fabrication. This analysis resulted in a division of these processes into: first, forming to shape; second, forming the joint area; and third, fastening the
joint surface area. The three headings were then subdivided, and each of them was in turn subdivided. (See chart Figure 1, on the following page.)

To these learning units, with their accompanying related and technical information, were added the common tools of education—reading, writing, and arithmetic. Reading and writing, in the usual sense, were taken for granted, but were supplemented from the graphic standpoint by shop drawing. Experience shows, however, that even a fair mastery of the third of the three "R's" cannot be presupposed. The average student cannot readily apply his grammar school arithmetic to simple shop problems.

A certain minimum of learning units fundamental to the field of industrial arts was selected without regard to local conditions of climate, community size, or industry.

These units, with their references, compiled in the form of a record syllabus are put in the hands of each student. In addition, considerable class discussion is used to point out the value of such a progress record in shop achievement. (Exhibit II, Appendix B). The syllabus becomes not
ANALYSIS CHART

Industrial Arts
Tool and Process
Phases of Fabrication

Forming to Shape

With Cutting Tools
- Lathe
- Milling Machine
- Drill Press
- Saw
- Abrasive Wheels
- Abrasive Belts
- Abrasive Coatings

By Bending
- Cold Bending
- Hot Bending
- Moulding
- Moulding to Shape
- Hammering
- Pressing
- Nailing

By Moulding
- Moulding to Shape

Fastening the Joint Area
- Screws
- Bolts
- Washers
- Nails
- Glue
- Soldering
- Rivets
- Adhesive
- Deep Filing
- Locks
- Patinas
- Grinding
- Polishing
- Melting and Flowing

Fig. 1
only the backbone of the integrated course but also a simple means for recording individual attainment.

To simplify clerical work, an ordinary ticket punch is used to record progress on each student's syllabus. The student has an opportunity to see how varied or how narrow his shop experiences are as compared with those of other members of the class. The par value in points given was established by arbitrary comparison of the tasks involved, but since only attainments within the group were considered, the point evaluation awarded each experience is of relatively minor importance. The student is constantly urged to apply these units of experience and reference study to his project work, rather than to look upon the project as an end in itself.

The record syllabus is a compact, eight-page booklet containing the learning units and references. These are grouped under the following headings:

Planning the Work
Lay-out Work
Tool Sharpening and Fitting
Cutting Materials by Hand
Cutting Materials by Power Machines
Forming by Hammering and Bending
Flowing Hot Metals
Fastening Work Together
Surface Coatings.

Marginal space is provided for the record punch marks. Seventy-four units, with their respective study references, are compiled under the above headings. Exhibit II, Appendix B, illustrates the arrangement.

BEGINNING CLASS INSTRUCTION

It was not at first intended to include arithmetic in this integrated shop course, but, as has already been stated, it was found that students lacked ability to apply mathematics to shop problems; consequently it was necessary to explain to each class that arithmetic is merely a shop tool needing to be cleaned and polished at the beginning of each school year.

During the first weeks of the term, the time varying according to the need, the entire class works on arithmetic. Drills on the multiplication tables, fractions, etc., are based on typical shop problems, and reference is made to books in the
shop library. The assigned problems include, for example, the calculation of the force in pounds exerted on a nail by a claw hammer; the pounds per square inch of surface pressure in the different parts of gas regulators; the determination of speeds of rotating parts and of moving surfaces, etc. This periodic review of mathematics not only starts the students on a definite work program on the first day of the term, but also instills an appreciation of scientific methods. Further during this review, the explanation of tools and equipment can be readily undertaken. After this period devoted to arithmetic, shop drawing is explained as a shop tool.

A definite attempt is made to enrich the drawing content by associating it with the layout tools and processes. For example, one may compare the purpose of squares and T-squares, the drawing triangles, mitre-try-squares and T-bevels, the drawing protractor, and the combination square protractor head. Detail of the drawing is illustrated in Appendix C. Throughout the year, emphasis on arithmetic and drawing is continued.
Drawing instruments to supply the entire class are within the budget limitations of the average shop, see list page 63, Appendix C. One set properly arranged in a cabinet may be used by all classes. In the school in which the author is employed, there are two shops using this type of drawing equipment for all their classes. In this case it was found more economical to make two portable cabinets, each containing one half of the equipment. Whenever necessary, during intensive drawing instruction, the total equipment thus becomes available to either class.

After these preliminaries, the students are ready to discuss Information Sheet No. 20, "Introduction to Shop" (Appendix C), which contains simple questions to be answered in writing. The informality of shop work necessitates such written material to be done on the job and handed in immediately. It is an essential part of the plan that this work be graded and returned to the student by the following day. This rapid correction of work encourages the boy and shows him that the teacher is interested in his individual progress. Use of the written report slip (Page 39, Appendix A) prevents later students from receiving direct
aid from the written work of others.

One of the major objectives of the general shop course is the development of an appreciation of tools and materials.

When a student enrolls in shop work, he is encouraged to take on a shopman's attitude in buying, making, and owning his own tool kit. Naturally the kit will at first be very limited, but it will grow by frequent additions.

Whenever possible, therefore, projects are selected from the field of tools. When a boy is instructed in the materials and construction of tools, he is really learning how to use them. Some common smaller tools, such as rules, twist drills, hack saw blades, etc., cannot, of course, be made by the beginner but must be purchased. A suitable tool container is needed and may be made from inexpensive crate lumber.

INTEGRATING THE COURSE

In the tool-box project the first step is the drawing of a plan. (Instruction Sheet No. 21, Appendix C). Instruction is limited to sawing and nailing, and no smoothing is allowed. Students
are reminded that these two operations are commonly regarded as too simple to need explanation. They are told that work on this project will reveal their background, alertness, and reference study.

The shop is sufficiently equipped with saw-horses, woodwork benches, and metal working benches so that twelve or fourteen students may start at the same time on their tool boxes. The faster students are, therefore, well on their way with construction by the time the slower ones have completed their drawings. This project, like many others in the course, is accompanied by written questions on reference study.

Working with wood has been, of course, the most common type of shop activity. Yet even in this work one uses metal tools. Therefore, after the tool box is made, the class is led to consider some phases of metallurgy; metallurgy thus becomes one of the many interests by means of which the instructor integrates the course. (Instruction Sheets 32, 35, and 40, Appendix C).

When eight or nine boys have finished their boxes, they are taken to the forging end of the shop where there are three homemade, natural gas
forges and nine anvils with anvil tools. (With the short one-hour period schedule, the gas forge is superior in speed and cleanliness to the coal forge.) Here, after a demonstration, the boys start work, learning the "feel" of hot iron. (Instruction Sheet No. 30, Appendix C). This introduces fire as an agency in the shop. The oxidizing and reducing actions of different parts of a flame are illustrated. The effects of raising materials to different temperatures are discussed. Thus the effects of flames and of temperature become, at this point, a further means for integrating the work. (Instruction Sheet No. 33, Appendix C).

Strict adherence to instructions, both written and demonstrated, is emphasized, yet full allowance is made for the student's natural tendency to experiment instead of following others' advice. The result is usually that the student comes to have an increased respect for the instruction sheet. Students are encouraged to restudy instructions whenever they do work of a similar character.

When the next eight or ten boys have completed their tool boxes, they are taken to the metal working
benches and are started on manipulation exercises, as listed on Page 11 to 17 of "Cold Metal Work" by E. Perry Van Leuven.

Individuals from both of these groups are allowed, as rapidly as they are able, to progress to succeeding jobs listed in sequence on the Assignment Sheets. (Exhibit I, Appendix B.)

Since spread in attainment continually widens, as the third group of eight or ten boys finish their project, they are gradually absorbed into the two groups already doing forging and bench work; many of the original members of these groups are by this time engaged in written work.

Here, to integrate the class work, the topic on the "Nature of Iron and Steel" (Information Sheet No. 32, Appendix C) is used for discussion. To vitalize this, such aids as moving picture films featuring the story of iron and steel--distributed by the United States Bureau of Mines at Washington D. C.--are employed.

Many other projects for the course are so designed as to aid in the integration process. A specific example is that of the tool-bit grinding gauge. (Instruction Sheet No. 44, Appendix C).
The making of this gauge, for nine different tool uses, integrates many associations regarding tools and characteristics of materials to be cut.

The beginning analysis showed that cutting operations consume the most time and present the greatest difficulty to the student. Therefore much time is devoted to cutting and cutting tools. Various applications of cutting processes provide further means for integration of the course.

(Information Sheet No. 52, Appendix C)

Another project to promote interest in tools is the forging of a screwdriver bit. (Instruction Sheet No. 45, Appendix C). A screwdriver is universally used and yet is one of the most difficult tools to keep in proper shape. The forging of a screwdriver requires only a few moments of the boy's time but provides a rich experience in proper tool shaping.

By the time a majority of the students have completed the first series of forge and bench jobs, they have acquired a fair amount of practical experience in cutting operations. Again the class is brought together for discussion, this time on the topic of "Characteristics of Cutting Tools".
The process of cutting affords one of the major opportunities for integration in the course.

From the divisions of work thus far described, students progress to work either in soldering, or in foundry molding, depending on available space. From this point, students are made increasingly aware that progress on their own initiative is the ideal toward which they should work.

Constant reference is made to the commercial relations of foreman and workman. Trips are taken to commercial shops. In all cases, attention is called to the fact that workmen are responsible for production and achievement, without unnecessary demand on the foreman's time. In the shop the instructor stands in place of the foreman. To the extent that the more capable students can perform their tasks on their own initiative, is it possible for the instructor to give supervision to those most needing his aid.

It is further explained that commercial progress is not wholly independent of the workman's ability to "forge" ahead without instruction. A congenial relationship between foreman and workman,
or teacher and student, is important. Too often, jobs in commercial work and grades in school work are lost, not because of the workman's or student's inability but because an unfortunate attitude exists between the parties concerned.

The student program is now extended to simple metal lathe operations and bench woodwork. The course organization thus far presented necessi-
tates for a diligent first year student one school year of work. An older student, taking shop for the first time, should naturally cover the work in a shorter period. The less ambitious student continues into the second school year or until he completes the course satisfactorily.

The more advanced integrated general shop attainments are listed in a second record syllabus. The student again progresses individually, as he did with the first record syllabus.

An additional record is permanently filed covering the entire high school shop career of the student. This record sheet (Exhibit III, Appendix B) uses the conventional trade classification and serves as an additional check on attainment. The record of the beginning work on this sheet is
compiled from the student's project record sheet and his record syllabus. The record of advanced work is compiled according to the criteria set up in the respective courses.

SUMMARY

In this plan for integrating shop work, great emphasis is placed on individual investigation, study, and progress. Students are faced with the fact that there are differences among them and that no individual desires to be dependent upon, or held back by, a group. A well-organized shop course, like a correspondence course, provides the student with comprehensive written instructions. The teacher, after all, is present merely to help students in the particular activities in which they are unable to direct themselves.

For the first few months the student's progress may seem unbearably slow. It is often difficult to recognize intangible accomplishment. Students coming from grammar school may feel that they have there been pushed and taught without reason. As high school freshmen, they are encouraged to solve their own problems. Apparent wasting of a few months, in which the students show only meager
displays of shop projects, will be more than offset later when those same students voluntarily study references bearing on their problems. It is better for a student to accomplish a little by his own efforts, than much by direct aid of the teacher.

The industrial arts course has too often been used merely to keep the boy busy making something that mother or sister would enjoy. This procedure, while probably pleasing to the mothers and sisters, has often caused a boy to be graduated from high school with the very decided handicap of not having learned the fundamentals of shop work.

In handling large classes, it is difficult for the instructor to hold each student responsible for his own attainment. The integrated program here presented, with assignments and individual record forms, provides for individual progress. Aids for shop organization and more complete details of the mechanics of the program are presented in the Appendix.
CONCLUSION

This thesis is an appeal for the establishment and emphasis of fundamental attainments in industrial arts. The use of the "general shop" to introduce this type of training is emphasized. The means for adapting the various phases of the conventional departmentalized shops to an integrated general shop program have been indicated at some length.

In the past six years the author has gradually introduced the integrated program here set forth and has observed the following changes: (1) Boys have become more versatile in their adaptation to shop problems. (2) Students have shown keener interest in the school shop. (3) Shop registration has substantially increased.

The program has gained high respect for shop work from both the local school administrators and the school board, and has attracted the attention of nearby school officials. This organized general shop course has gained, from those in charge of student matriculation, a consideration equal to that given to other school departments. That is, beginning shop is no longer a "dumping ground".
Older students coming from other schools with credits in beginning or advanced shop, have, in many cases, voluntarily requested admission to the integrated general shop course, although they could receive at most only partial credit.

With the use of the teaching aids and course organization here presented, the work of the teacher has become not so much a matter of "driving" as one of directing. The record syllabus and assignment sheets give the student greater freedom for individual progress. The use of well-prepared instruction sheets, references, models and charts, together with checking, testing, and recording aids, provides the instructor with the necessary additional time for personal supervision. This method of organization develops appreciation of the interrelationship of industrial processes, and integrates the learning attainments. The boy's interest in his attainment is increased because of the wide association offered by a comparison of the shop processes with one another.

Although a number of sheets of instruction and assignments are included in the Appendix, the course is not presented in full. It is recognized
that an instructor's own development in teaching technique is what gives him enthusiasm for his work. The author hopes that the contribution here offered may inspire other instructors to aid in making industrial arts one of the "tool" subjects of education, a matter which, he believes, is of paramount importance in the present industrial age.

RECOMMENDATIONS

The author recommends that the disconnected parts of today's conventional beginning shop courses be replaced by a unit course perhaps given some other name than "general shop", but emphasizing the points of view set forth in this thesis. This contemplates that the beginning shop course be just as comprehensive in the field of materials and processes as the course in general science is in its field.

To accomplish this, two objectives must be attained: (1) The course content must not be the result of one man's work as is that indicated in this thesis, but must be determined by combining the results of many investigators. (2) Instructors of shop courses must be imbued with the ideals set forth herein and must be led to recognize their hitherto neglected opportunity in the field of
general secondary education.
APPENDIX A

AIDS TO SHOP INSTRUCTION

Shop work organization is based on the following type of equipment for approximately thirty students:

1. Thirty seats.

2. Major equipment: two large woodwork benches with eight vises; adequate saw horses; one small circular saw table; four metal-working benches with eight machinist vises; one electric bench drill; one slow speed floor drill press; three forges (gas forges preferred); nine anvils; anvil tools, such as hammers, tongs, and hardies; one large well anchored vise; one each of special anvil tools such as eyed chisels, eyed punches, fullers, and swages; soldering furnace; bar folder; forming rolls; forming stakes; one combination rotary machine; squaring shears; heavy bench shears; bin for aluminum molding sand to accommodate four; one small shop-made crucible furnace; one number nine graphite crucible; molder's riddles, slicks and flasks;
simple patterns for solid, split and cored pattern sand molding; one small second-hand single burner gas oven; one screw-cutting engine lathe; one electric grinder; one hand grindstone.

These tools, whether new or second-hand, should be kept in good condition, well painted, and labeled with the name of the tool and a reference to its use.

3. Hand equipment: hand saws; auger bits; twist drills; hack saw frames without blades; wood chisels; hand planes; various shaped double cut files; tap and die set; one or two small reamers; pipe dies; pipe wrenches; nail hammers and machinist hammers; lead and wood mallets; tinner's riveting and setting-down hammers; 16 x 24 inch framing square; 12 inch square; 6 inch try-square; marking gauge; outside and inside caliper; hermaphrodite caliper; divider; screw pitch gauge; T-bevel; combination bevel-protractor; small micrometer.

4. Student's own kit: (these items will be accumulated over a period of time. Many of them are made by the student, others are
brought from home, and still others are purchased through the school or direct from a hardware dealer; shop garment (the shop garment is a project which helps to integrate the shop and sewing departments of the school. The shop department buys eight-ounce white ducking by the bolt and sells the finished apron to the students at cost. The sewing department uses the apron as a beginning sewing project.) tool kit box; a pencil; loose-leaf binder; small ten cent folding steel rule; a hack-saw blade; a ten inch mill file; 1/8 inch twist drill; 3/16 inch twist drill; 1/4 inch twist drill; 8 inch combination pliers; soap stone; waste cloth; scriber; bradawl; rivet set; center punch; tool bit grinding gauge, (Instruction Sheet No. 44, Appendix C); countersink; screw driver; cold chisel; solder; solder flux; nail set; wood chisel; hack saw frame. Additional useful tools should be encouraged wherever a boy's means and needs warrant such recommendation.

The shop hand tools are grouped in three divisions to facilitate integration of instruction:
1. lay-out tools
2. cutting tools
3. miscellaneous tools such as hammers, mallets, bit braces, hack saw frames, hand seamers, pliers, wrenches, screwdrivers, etc.

Each group of tools should have a well arranged tool board, with both tool shadows and tool name neatly painted on it. The lay-out tools are on one tool panel, Figure 2; the miscellaneous tools on another; and the cutting tools, together with the supply materials, are kept in the supply room. The panels for lay-out tools and miscellaneous tools are open in the main shop and accessible to the students at all times. The cutting tools are kept in the supply room, as an aid not only to the control of their use, but also to instruction. Much emphasis is given to the cutting process and to the importance of cutting tools, their care and use. A clerk is in charge of
the supply room and a checking system is used for all
items taken from the room. A sample order slip
follows:

<table>
<thead>
<tr>
<th>Name</th>
<th>To be returned</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td>Not to be returned</td>
</tr>
<tr>
<td>Quantity</td>
<td>Description Size</td>
</tr>
<tr>
<td></td>
<td>0, K'd</td>
</tr>
</tbody>
</table>

**Fig. 3 STOCK ROOM ORDER SLIP**

This order slip is first filled out by the student
needed the supply room item. The instructor
indicates approval by marking the order slip
with a ticket punch.

The value of this stock room order slip is
three-fold. First, it is an aid in keeping the
teacher in close contact with the individual student's
progress. Second, it gives opportunity for the
teacher to analyze that student's problem and
to see that he is asking for the cutting tool or
item of material which he should use. Such
procedure eliminates misuse of tools and material.
Third, it gives the student practice in proper spelling and naming of shop items. The supply room clerk is authorized not to issue any item without the instructor's punched "O.K."

Every attempt is made to minimize student costs. Small items of mild steel and scrap wood are given free. Even small amounts of tool steel and cold rolled steel, such as for bradawls, scribers, tool bit gauges, and similar projects, are likewise given without cost. For later projects, nominal charges are made for materials and tools the student buys from the school supply room; such as, hack saw blades, mill files, twist drills, ten cent steel rules, etc.,

To facilitate collections of money and payment for supplies a shop ticket is used, (Figures 4 and 5). These tickets are made up in two denominations of

Fig. 4 50¢ SHOP TICKET
fifty cents and one dollar. The student may pay for the ticket when he receives it or he may establish a charge account. This ticket is stapled to the student's notebook. When small and insignificant shop items are purchased, the instructor merely uses his ticket punch on the ticket card. This greatly minimizes the bookkeeping of shop accounts.

So far as possible all assignments are accompanied by a few brief questions to be answered in writing only after the student has studied his reference work and completed his experiment or project. To permit individual progress in this written question work, each student is required to turn in the answers promptly, at the completion of the work. They are then corrected by the teacher and the results are returned promptly to the student.
That the work may be used for later students, answer sheets are never returned to the student; instead report slips giving a record of incorrect answers or in-completed work are handed to him. (Figure 6)

For each assignment of written questions, individual grades are recorded in the teacher's class book. This book is always accessible to the student, and with the student's own report slips, keeps him constantly informed as to his accomplishment in written study work.

Upon completion of the various phases of his project, the student has his record syllabus punched
by the instructor.
It thus becomes
a constant
indication of
the student's
attainment.
The syllabus
is kept in
each boy's
tool kit, and
must not be
taken from the
shop. (Fig. 7)
After the
boys learn the
importance of
keeping their
record syllabus punched daily, the matter of
recording becomes simple. A few questions at the
time the record is punched will show the teacher
whether the boy has his information well in hand
or is merely bluffing.
Library material is placed in the shop and is accessible at all times. The volumes are arranged alphabetically by authors. The books are also numbered to correspond with the book stall numbers, which helps to facilitate the self-administration of the library. (Figure 8)
Various types of instruction charts, such as the Stanley Rule and Level Company's charts, and instruction charts with models of work, are placed on a hinged pedestal in the center of a round table. (Figure 9)
PROCEDURE STEPS

Project models of the steps of procedure and of the finished project, and of qualities of work both acceptable and unacceptable are exhibited on these various charts. (Figures 10 and 11)

Fig. 10

Fig. 11 FITTING HAMMER HANDLES
Experimental equipment is also made constantly accessible; for example, a magnifying glass for looking at the grain sizes of broken tips of tool samples. (Figure 12)

Each tool of carbon steel must be made long enough at the heat-treated end that a sample tip may be broken off to give a grain-size test of the quality of the forging and the heat treatment. (Figure 12)
An old file is stationed by a short chain, always accessible for the file test on heat-treated work. (Figure 13)
Magnets are accessible for determining the critical temperature in all heating operations of steel. A strip of polished steel is actually colored by heat oxide colors, covered with lacquer, and mounted on a panel. (Figure 14)

At one side of the strip of steel is listed the approximate degrees of heat represented by each color. At the other side is listed groups of common tools which should be heat-treated to the tempers represented by each heat color.
Spring scales are used to test the resistance to bending strain, on the points of scribers and bradawls. (Figure 15) If the heat treatment has left them too soft or too hard, their slender points when pressed against the scales at a slight angle of about 20° from horizontal will either bend or break off at from 5 to 8 pounds pull. A successful job of heat treatment on these two tools, will pull the scales from 12 to 16 pounds without damage to the tool point. These types of simple tests give a scientific method which displaces the too common habit of guess work.
A speed indicator is kept accessible that boys may obtain a first-hand conception of the speeds of rotating parts or of moving surfaces. To broaden the student's comparisons of metals, a heat conduction comparer, such as is used by most physics laboratories, is also kept accessible. The conduction comparer aids in developing the conceptions of welding, hard soldering, and soft soldering and helps to explain the purposes of soldering coppers and fluxes.

The students proceed in their work as directed by the assignment sheets, which follow in Appendix B. Their project record is included in these sheets. The instructor's punch mark indicates the approval of the finished project or assigned job.

Examples of the instruction material for these assignments will be found in Appendix C. Much of the mimeograph and drawing work is done by students from those respective departments who had little or no training in shop or in drawing. For the sake of economy, therefore, techniques have been sacrificed in the making of drawings and instruction sheets.
APPENDIX B

COURSE ASSIGNMENT AND RECORD FORMS

EXHIBIT I

THE STUDENT'S ASSIGNMENT SHEETS

AND PROJECT RECORD
# BEGINNING SHOP

## Student's Assignment Sheet and Project Record

### Of Student

#### Sheet 1 of 6

<table>
<thead>
<tr>
<th>Desired</th>
<th>Acceptable</th>
<th>Unsatisfactory</th>
</tr>
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<tbody>
<tr>
<td>Your Work</td>
<td>The following Assignments covering your shop work will be explained in the attached sheets and references. You should progress as rapidly as you can and have each assignment checked off by your instructor as rapidly as it is approved.</td>
<td></td>
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</table>

## I Shop Drawing

- **Instruction Sheet No. 1**, Drawing Horizontal Lines.
- **Instruction Sheet No. 2**, Drawing Vertical Lines.
- **Instruction Sheet No. 3a**, Orthographic Projection.
- **Instruction Sheet No. 3b**, Orthographic Projection.
- **Instruction Sheet No. 4**, Scale Drawing.
- **Instruction Sheet No. 5**, Showing Small Detail.
- **Instruction Sheet No. 6**, Showing Small Detail.
- **Instruction Sheet No. 7**, Showing Small Detail.
- **Instruction Sheet No. 8**, Degrees.
- **Instruction Sheet No. 9**, Isometric Drawing.
- **Instruction Sheet No. 10**, Isometric Drawing.

**Drawing Summary Questions**
BEGINNING SHOP

Student's Assignment Sheet
and Project Record

Of Student ____________________________
Sheet 2 of 6

<table>
<thead>
<tr>
<th>Your Work</th>
<th>Desirable</th>
<th>Acceptable</th>
<th>Unacceptable</th>
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</table>

Drawing Test

II Introduction to Shop, Information Sheet No. 20.

III Tool Box, Instruction Sheet No. 21

IV First Series of Assignments

Note:

Proceed in your shop work by following through this First Series of Assignments. Follow the Series of Assignments in the order in which they occur, including the Information Sheets, Instruction Sheets and Reference Jobs. However, you will notice some assignments marked with an asterisk (*) and others with an "x". The first time that you work through the First Series, you should omit those assignments marked with one of the marks, either (*) or (x) as assigned by your instructor. Then work through the First Series again, to cover the work you omitted the first time. Thus after the First Series of Assignments are completed you may start the Second Series and work
<table>
<thead>
<tr>
<th>Your Work</th>
<th>Desirable</th>
<th>Acceptable</th>
<th>Unsatisfactory</th>
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<tbody>
<tr>
<td>Student's Assignment Sheet and Project Record</td>
<td>Of Student ____________________</td>
<td></td>
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<tr>
<td>Sheet 3 of 6</td>
<td>forward at your own best speed for doing thorough work.</td>
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<tr>
<td>* Instruction Sheet No. 30, &quot;Feel&quot; of Hot Iron.</td>
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<tr>
<td>Instruction Sheet No. 33, Fire.</td>
<td>Information Sheet No. 35, Heating of Iron and Steel.</td>
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<td>x Job No. 34, 6 ga. Wire Handle, E. Perry Van Leuven, &quot;Cold Metal Work&quot;, pp. 11-17.</td>
<td>Information Sheet No. 36, Filing.</td>
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<td></td>
</tr>
<tr>
<td>* Instruction Sheet No. 37, Center Punch.</td>
<td>* Instruction Sheet No. 38, Scriber.</td>
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<tr>
<td>* Instruction Sheet No. 39, Forging a Flat Taper.</td>
<td>* Instruction Sheet No. 40, Heating Carbon Steel.</td>
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</tr>
<tr>
<td>x Job Sheet No. 41, Bradawl; follow the same procedure as for the Scriber and use the blue print and model chart for the Bradawl, at the round table.</td>
<td>* Instruction Sheet No. 42, Cold Chisel.</td>
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<tr>
<td>* Instruction Sheet No. 43, Countersink.</td>
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### Your Work

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</table>

#### Instruction Sheet No. 44, Tool Bit Grinding Gauge.

#### Instruction Sheet No. 45, Screw Driver Bit.

#### V Second Series of Assignments

Job No. 50, Rivet Set, E. Perry Van Leuven "Cold Metal Work", pp. 126-127. Choose either carbon steel @ 30¢ per lb. or mild steel @ 10¢ per lb.

Instruction Sheet No. 51, Nail Set.

Information Sheet No. 52, Characteristics of Cutting Tools.

Job No. 53, Grind Your Center Punch, Cold Chisel and Countersink by using your own tool grinding gauge and the reference given for each tool in your Record Syllabus under Tool Sharpening.

Job No. 54, Soldering Copper, refer to the instruction and model chart at the round table.

Job No. 55, Resume your Instruction Sheet No. 44, and finish your Tool Bit Grinding Gauge by using your own center punch countersink, and rivet set that you have made.

Instruction Sheet No. 56, Wood Chisel.

Instruction Sheet No. 57, Fitting Screw Driver Ferrule and Handle.

Instruction Sheet No. 58, Tapping Internal Screw Threads.
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<th>Your Work</th>
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<td></td>
<td>Of Student _______________________________</td>
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<tr>
<td>Sheet 5 of 6</td>
<td></td>
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</table>

<p>| Instruction Sheet No. 59, Cutting External Screw Threads. |
| Instruction Sheet No. 60, Hack Saw Frame. |
| Instruction Sheet No. 61, Cutting External Pipe Threads. |
| Job No. 62, Refer to E. Perry Van Leuven, &quot;Cold Metal Work&quot;, pp. 75-80, and do any one of the Jobs specified. |
| Job No. 63, Refer to E. Perry Van Leuven, &quot;Cold Metal Work&quot;, pp. 55-70, and Bell &amp; Shaeffer &quot;Introductory Metalworking Problems&quot;, pp. 15, and do any one of the jobs specified. |
| Information Sheet No. 64, Solder and Soldering |
| Instruction Sheet No. 65, Soldering Kit |
| Job Sheet No. 66, Your choice of simple soldering projects as you choose, with your instructor's approval, from project references in our shop library. |
| Instruction Sheet No. 67, Cast Aluminum Towel Bracket. |
| Instruction Sheet No. 68, Cast Aluminum Marking Gauge. |
| Instruction Sheet No. 69, Cast Aluminum Key Hole Saw Handle. |
| Job No. 70, Cast Aluminum Hack Saw Handle, as per blue print and model at the shop round table. |
| Instruction Sheet No. 80, Sand Paper Block. |</p>
<table>
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<th>Your Work</th>
<th>BEG-INNING SHOP</th>
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<td>Of Student________________________________</td>
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<td>Sheet 6 of 6</td>
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<td></td>
<td>Job No. 81, Choose one project from the following references; Harold R. Wise &quot;Elementary Woodworking Projects&quot; pp. 32, 34, 44, 48, 56. Louis M. Roehl, &quot;Problems for School and Home Workshop&quot;, pp. 13,15,27.</td>
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<tr>
<td></td>
<td>Job No. 82, Choose a project such as the following reference suggestions; Harold R. Wise &quot;Elementary Woodworking Projects&quot;, pp. 36, 40, 60, 62, 70, 72, 74, 112. Louis M. Roehl, &quot;Problems for School and Home Workshop&quot; pp. 35, 41, 49, 83.</td>
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<tr>
<td></td>
<td>Instruction Sheet No. 83, Test in Layout Work and Cutting.</td>
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<td>Information Sheet No. 90, Finishes.</td>
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<td>Instruction Sheet No. 91, Finishing.</td>
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</table>
EXHIBIT II

THE RECORD SYLLABUS

(Only a few sample sheets are here shown to illustrate the arrangement of the syllabus)
**RECORD SYLLABUS**

**INDEX**

<table>
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<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
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<td>Explanation of your Record Syllabus</td>
<td>1</td>
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<tr>
<td>Six Week Report Records</td>
<td>1</td>
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<tr>
<td>Record of your Personal Pride and Responsibility</td>
<td>2</td>
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<tr>
<td>Experiences of Ownership</td>
<td>2</td>
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<tr>
<td>Key to Reference Abbreviations</td>
<td>3</td>
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<td>Planning Your Work</td>
<td>4</td>
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<td>Lay-Out Work</td>
<td>4 &amp; 5</td>
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<tr>
<td>Tool Sharpening and Fitting</td>
<td>5</td>
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<tr>
<td>Cutting Materials by Hand</td>
<td>5 &amp; 6</td>
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<tr>
<td>Cutting Materials by Power Machines</td>
<td>7</td>
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<tr>
<td>Forming by Hammering and Bending</td>
<td>7 &amp; 8</td>
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<tr>
<td>Flowing Hot Metals</td>
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<td>Fastening Work Together</td>
<td>9</td>
</tr>
<tr>
<td>Surface Coatings</td>
<td>9</td>
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</table>
RECORD SYLLABUS

Keep this Record Syllabus in your tool kit.

Your number of "School Credits" in Beginning Shop will be in proportion to the total of your "Points in Experience" as recorded in this Syllabus, plus the results of your study and examinations in technical information.

In the right margin is recorded the quality of your work; i. e. -
A - a standard of work that consumers are in search for.
C - work of an easy standard to attain.
D - work that people would not like to pay for.

In the left margin is recorded the quantity or comparative size or extent of any particular experience; i. e. -
1 small job, not much experience gained.
3 enough experience to indicate that you understand the task involved.
5 experience demanding exceptional skill; or experience involving sufficient repetition to develop skill.

(points par indicate the usual value)

On the blank lines of your Syllabus name the job and (or) tool with which the experience was attempted.

Additional points for quality "C" or better:
First trial 3 points.
Second trial 1 point.
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<thead>
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<th>135</th>
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<th>A</th>
<th>C</th>
<th>D</th>
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<tr>
<td></td>
<td>(5 par) With Steel Stamps (Use on steel only when it is annealed soft)</td>
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<tr>
<td></td>
<td>TOOL SHARPENING AND FITTING</td>
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<tr>
<td></td>
<td>(3 par) Wood Chisel (same as plane iron)</td>
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<td>(3 par) Metal Chisels. E.S. - P 148-150. In. Ch. 53-54.</td>
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<td>(3 par) Center Punches. E.S. - P 147. Fig. 105.</td>
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<td>(3 par) Prick Punches. V.L. - P 15.</td>
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<td>(3 par) Solid Punches.</td>
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<td>Knife Ground &amp; Whetted (same as plane iron)</td>
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<td>(3 par) Screw Driver Bit. B. &amp; T. - P 158-159; In. Ch. 119.</td>
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<td>(3 par) Auger Bit Spurs &amp; Lips Filed. B. &amp; T. 119-122; In. Ch. 117.</td>
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<td>(5 par) Countersinks. V.L. - P 58-59; E. S. - P 271.</td>
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<td>(5 par) Bradawl (as per blueprint)</td>
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<td>(5 par) Fitting Tool Handles. R. - P 297-300.</td>
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<td>CUTTING MATERIALS BY HAND</td>
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<td>(1 to 3 par) Sawing Wood to a line at a predetermined angle. B.&amp; T. Unit 7; In. Ch. 98-99.</td>
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<td>(1 to 3 par) Sawing Metal at definite angles. V.L. P. 29-33.</td>
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<td>(1 to 3 par) Planing Wood. In. Ch. 115-116; B.&amp; T. Units 13-16.</td>
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<td>(1 to 3 par) Boring Auger Bit Holes. In. Ch. 117; B.&amp; T. Unit 22.</td>
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<td>(1 par) Cutting on a Hardie, Hot Stock. E. S. 34-35; L.C.J. 57-58; V.L. 75-77.</td>
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<td>(5 par) Hand Drilling in Metal. V.L.P. 40-53; B.&amp; T. Unit 23.</td>
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<td>(3 par) Cutting Screw Threads with a Die V. L. 110-116; and above reference.</td>
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<td>CUTTING MATERIALS BY POWER MACHINES</td>
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<td>(5 par) Drilling Holes by Power Feed Press. 'Handbook for Drillers.' In. Ch. 95.</td>
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<td>FORMING BY HAMMERING AND BENDING</td>
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<td>(3 par) Fitting Forge Tongs to Work. L.C.J. P. 4-6.</td>
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<td>(3 par) Drawing a Flat Taper to Dimensions E.S. 33-35; L.C.J. 61-63.</td>
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<td>(3 par) Forging to Round Shape to Dimensions. E.S. 35, 37, 39; L.C.J. 127-129.</td>
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<td>(3 par) Vise Bending to Dimensions. V.L. Pages 9, 12, 13, 20, 28, 29, 34, 35, 38, 39, 47, 48.</td>
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<td>(5 par) Carbonizing and Case Hardening. L.C.J. 98; E.S. 144; H.A.J. Book I P. 72; 82-85.</td>
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<td>(5 par) Stake Forming Sheet Metal. S. &amp; C. 55.</td>
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EXHIBIT III

HIGH SCHOOL SHOP RECORD

(This form is based on the conventional trade classification and is used as an additional check on the attainment through the general shop program for permanent file.)
The record of ____________, from 19__ to 19__ is listed according to his scholastic years of shop attendance.

(a) indicates that he has attempted the work without satisfactory accomplishment.

(s) indicates that his attainment has been satisfactory.

(*) indicates the phases of the course in Beginning Shop that must be accomplished before registering for any further shop courses.

### BEGINNING GENERAL SHOP

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### ADVANCED SHOP

Voc. Math. any phases of adv. gen. shop

mech. drawing

furniture & cabinet work auto mech.

carpentry & blg. constr. farm mech.

electricity concrete work
APPENDIX C

EXAMPLES OF INSTRUCTIONAL MATERIAL

The detailed instructional material for the course is not here presented in its entirety. Appendix C consists only of examples of such material, most of which has been referred to from Chapter II and Appendix A of the thesis.

The instructional material is pursued according to the sequence listed in the assignments sheets of Appendix B, Exhibit I.
APPENDIX C

EXAMPLES OF INSTRUCTIONAL MATERIAL

STARTING THE CLASS IN SHOP DRAWING

The first period of shop drawing is spent according to the following lesson plan:

I Discussion as to content of early grammar schooling

1. Learning to speak and write the mother tongue.
2. Use
   (a) By laymen
   (b) By English professors, authors, and journalists

II Discussion of graphic language of shop drawing.

1. Purpose
2. Use

III Explanation with discussion as to cost and use of drawing equipment.

1. Drawing board
2. T-square
3. Triangles
4. Pencil compass
5. Protractor
6. Scale rule
7. Paper
8. Thumb tacks
9. Pencil

IV The above equipment is assigned, and "check in" clerks are appointed for the close of each
period.

V. Demonstration is given on placing of paper and actual use and importance of T-square, triangles, and pencil.

The following day, job sheets are distributed and a demonstration given in the use of the job sheet plan of instruction. From that time on, both individual and group progress is encouraged. Study questions are emphasized and attention is called also to the summary questions at the end of the job sheets. It is explained that a final test will be given to cover that material. A sample of which follows the summary questions.

Following is a list of drawing equipment used in proportion to the number of students.

Shop Drawing Equipment

1 drawing board for each student
1 inexpensive T-square for each student
1 45 degree triangle for every two students
1 30-60 degree triangle for every two students
1 pencil for each student, either a 3H or a 4H
1 protractor for every four students
1 scale-rule for every student
1 roll of wrapping paper, light manila color
Thumb tacks
DRAWING HORIZONTAL LINES

Sheet 1 of 2 Drawing Instruction Sheet No. 1

PURPOSE

1. To learn the proper position in which to use the drawing board, paper, and T-square.
2. To learn to measure accurately.
3. To learn the proper direction in which to draw horizontal lines.

PROCEDURE

1. Correct "form" enables you to learn readily to swim, play basket ball, or achieve in track or golf. The following "form" enables you to draw with greater speed and accuracy.

2. Keep a true edge of the drawing board to your left.

3. Tack your paper close to the top and left edges.

4. Either sit on a high stool or stand so you can see accurately as you work.

5. Always use your T-square with the head against the left edge of your board.

6. Draw horizontal lines by moving your pencil from left to right against the top edge only of your T-square.

7. Draw very light lines; No. 4H pencil lead hardness is recommended, and DO NOT PRESS HEAVY INDENTED LINES.

8. Write your name and Sheet No. 1 in lower right corner.

9. Begin near the top of your sheet and draw horizontal parallel lines as follows:
DRAWING HORIZONTAL LINES

Sheet 2 of 2

Drawing Instruction Sheet No. 1

2 lines 1" apart 6" long; 3 lines 1/2" apart 7 1/2" long; 3 lines 3/4" apart 6 1/2" long; 3 lines 5/8" apart 8" long; 3 lines 5/16" apart 4" long; 3 lines 3/16" apart 4" long; 3 lines 1/8" apart and 4 7/16" long; label all lines according to the above specified dimensions. To gain clearer understanding refer also to General Shop Handbook, by Willoughby & Chamberlain Page 17, Unit 5, Paragraph C.

Write brief answers to the following questions:

1. State from memory the purpose of your drawing Instruction Sheet No. 1.

2. Why should the T-square be used against the true edge of your drawing board?

3. Why should paper be tacked close to the top edge of the drawing board?

4. Why must a person be high enough to see a drawing from directly above it as he works?

5. Why must a T-square head be used against the left edge of your board?

6. Why should your pencil move from left to right for drawing horizontal lines?

7. Why should lines be drawn lightly without indentions?

8. Why is good "form" necessary in learning to draw?
PURPOSE

1. To learn the proper position in which to use the T-square and vertical side of a triangle.

2. To practice measuring accurately.

3. To learn the proper direction to draw vertical lines.

PROCEDURE

1. Hold your T-square in proper position against your board and near the bottom of your sheet.

2. Place a triangle against the upper edge of your T-square with a vertical edge to your left.

3. Hold both T-square and triangle with your left hand.

4. Draw all vertical lines from bottom toward top and against a left vertical edge of a triangle.

5. Write your name and Sheet No. 2 in lower right corner.

6. Begin near the left side of your sheet and draw vertical lines to the same specifications as for Sheet No. 1.

References for additional study: General Shop Handbook, by Willoughby & Chamberlain, P. 17, Unit 5, Paragraph D.

Write brief answers to the following questions:

1. Why should your sheet always be tacked close to the left edge of your drawing board?

2. Why should the triangle and T-square be held with your left hand?
3. Why should your triangle always be placed with a vertical edge to the left for drawing vertical lines?

4. Why should you always draw vertical lines from the bottom toward the top?

5. Why should your paper always be tacked close to the top edge of your board?
PURPOSE
1. To learn the meaning of "views" on shop (orthographic) drawings.
2. To learn the proper order to arrange views.
3. To learn how to use dimensions.

PROCEDURE
1. Notice that the orthographic projection of three surfaces is the important drawing for shop work.
2. Notice the two types of drawing of a chest below.

3. Notice that you look at each projected view from a perpendicular angle to its surface. This allows a true measurement and dimension for that surface.
4. Notice that this perpendicular angle from which you look at each surface allows true dimensions of each surface.
5. Notice that the top view, the side view and the end view are projected from one another in an exact arrangement.

6. Notice the different weight of lines. They differ by using harder and softer pencils, and not by difference of pressure.

7. Notice that dimensions are placed between views and below views.

8. Notice that dimension arrows touch lines that project accurately from the views.

9. Notice that dimensions always read from the bottom and from the right of your sheet.

10. Reproduce a 3 view orthographic projection of the above chest.

11. Let 1"=12" in your drawing to give a proportionate scale size to the dimensions of the chest.

12. Write your name and Sheet No. 3 in lower right corner.

References to help you:
School and Home Shopwork, Schultz & Schultz, P. 18-23, Ex. 3; Instruction and Information Units for Hand Woodworking, Douglas & Roberts, P. 20-22; Instruction Unit No. 1, Section B.

Write brief answers neatly to the following questions:

1. A box or a chest has three general dimensions known as height, width and length. Which two of these dimensions are seen in the top view?

2. Which two of these dimensions are seen in the side view?

3. Which two of these dimensions are seen in the end view?

4. What help is it to use two weights of pencil lines?
5. Why should heavy pressure not be used on a pencil?

6. Why should dimensions be placed between views whenever it is convenient?

7. Where should dimension arrows stop?

8. How should dimension figures be placed for vertical dimension lines?

9. When planning your paper space for three projection views of an orthographic drawing how can you estimate the size of space required? For example, which two of the general dimensions do you find across the width of your paper, and which two do you find across the height of your paper?
The following drawing Job Sheet, No. 3b, is used for repetition drill work in the oral demonstration that was used with Job Sheet No. 3a. The class is divided into groups of five or six students including their leader. The leader is responsible for holding the group together. The required number of leaders are chosen by the members of the class from the students who showed the greatest accuracy and speed on the previous Job Sheets. This method of drill gives the slower type of student encouragement for careful observance of instructions both written and oral.
PURPOSE:
1. To drill for speed in the work of Job Sheet 3a.
2. To profit individually by "team work" in the shop.

PROCEDURE:
1. Select your leader from your drawing group.
2. Secure an object for drawing from your instructor.
3. Secure drawing paper, tacks and all your necessary drawing equipment and get it into position to use promptly.
4. Do your work in unison as a group as directed by your drawing group leader in the following order:
   (a) Tack your paper near the upper left corner of your board.
   (b) Decide with the group what 3 views to project of your object.
   (c) Without any measuring or straight edge sketch freehand and very lightly all 3 views in their approximate position.
   (d) Now with T-square in position draw a base or starting line to represent the bottom outline of your object, extend this line lightly completely across your paper.
   (e) Measure from your base outline the height of your object.
   (f) Draw the top outline of your object through this point of height measurement as in step (d).
   (g) Continue your drawing by this line by line method in unison as a group until you finish all 3 views in projection.
   (h) Put the necessary dimension lines and dimensions in place.
   (i) Give your name and the name of the object drawn on your sheet.
5. Decide as a group with your leader in charge when all the drawings of the group are correct.

6. The group leader should call the instructor to the group for presentation of the work.

Note:
A variety of objects of both wood and metal should be drawn in group team practice in the above manner. Secure more objects from your instructor.
PURPOSE

1. To learn to draw details of construction.
2. To learn to use hidden lines.

PROCEDURE

1. Notice the two orthographic projection drawings A. and B. below, of the same box in each case.

A. Without Construction Details
2. Notice that the outlines of the views are identical in both A. and B., but B. has the boards of construction. The thickness of the boards are shown just inside the outlines of the box.

3. Notice the definite fit of the butt joints of the boards.

4. Draw a 3 view orthographic projection of this box showing complete detail.

5. Use the largest scale your sheet will permit.
6. Draw the outline of all three views first.

7. Then draw in all boards until the detail of each view is shown complete.

8. Notice the use of a hidden line.

9. Notice that a hidden line must be distinct short dashes and not dots.

10. Write the title of your drawing, the scale, and your name at the bottom of your sheet.
Summary of Beginning Shop Drawing

Your examination in drawing will cover the following points from your study in drawing:

1. Explain the marks for indicating the hardness and softness of pencils.

2. Why should we use a certain hardness of pencil for the first layout of a drawing and then one of different hardness for finishing the object outlines and specifications?

3. In what position should the T-square always be used?

4. What are the various directions for pencil movement in drawing lines?

5. Explain the use of linear measure.

6. Explain the use of degree measure.

7. Name and make examples of five most common lines used in drawing.

8. Explain the use of five most common lines.

9. Describe the fundamental axes for isometric views.

10. Explain the difference between isometric views and orthographic views.

11. Explain and compare the purpose of isometric views and orthographic views.

12. Why should all the orthographic views be drawn at the same time and on the same extensions?

13. How can orthographic views be constructed to an advantage at the same time?
14. How are holes dimensioned for location on a layout or on a drawing?

15. How are holes dimensioned for size?

16. What is the chief difference between drawing work and layout work?

17. Describe how and why different "Scales" are used in drawing.

18. Why should there be difference in weight or darkness of various kinds of lines in a finished drawing?

19. What is the value of orthographic projection drawing as compared to other types?

20. Explain and compare the use of: T-square, try-square; triangles, mitre square; rule, scale rule; protractor, bevel-protractor, T-bevel.
BEGINNING SHOP DRAWING

TEST

Name ____________________________

Date ____________________________ Write answers on blank lines only

Score 84: total score

Grade A __________________________

1. Which is the hardest of these numbers of pencils, 2H, 3B, 5B, H, 4H, or 6B? 4H

2. Which is the softest of the above numbered pencils? 6B

3. Which grade of pencil hardness should be used for finishing the object of a drawing, lettering, dimensions, arrow heads? 2H

4. Which grade of pencil hardness should be used for the first layout of a drawing? 4H

5. Should enough pressure be applied on the pencil to make indentation on the paper? 2H

6. Against which edge of the board should the head of the T-square be placed if horizontal lines are to be drawn? left

7. (Ditto) If vertical lines are to be drawn? left

8. When should a T-square be used with the head against either the top or bottom edge of the drawing board? never

9. When should one use the top edge of a T-square for ruling? always

10. When should one use the bottom edge for ruling? never

11. What should be the direction of movement when ruling a horizontal line? left to right

12. What should be the direction of movement when ruling a vertical line? bottom to top

13. How much does a good quality drawing pencil cost? 104
14. Degree is the unit of measure used to determine the space between parallel or un-parallel lines?

15. Draw a sample visible object line.

16. Draw a sample invisible object line.

17. Draw a sample projection line.

18. Draw a sample dimension line.

19. Draw a sample center line.

20. Isometric drawing shows 3 planes or surfaces of an object. How many degrees with horizontal are the three fundamental angles for isometric drawing?

   (1) 90° vertical
   (2) 24° at 30°

21. If an object has beveled or tapered surfaces can it be drawn in an isometric view?

   Yes

22. Can the beveled or tapered surface of an object be drawn at the same angle of either of the two fundamental isometric angles?

   No

23. Will non-isometric lines of an isometric drawing measure a length in true proportion to the rest of the drawing lines of the object?

   No

24. Which of the following 5 tools should be used for each of the following 6 jobs?

   5 tools
   Try square, mitre square, sliding T-bevel, protractor, bevel protractor.

   6 jobs
   1. To lay out an exact angle on a drawing
   2. To lay out a 45 degree angle mitre cut on a narrow piece of stock?
3. To lay out an odd angle roughly on a __________ piece of stock.
4. To transfer an odd angle roughly from one piece of stock to another.
5. To lay out an odd angle on stock with great accuracy.
6. To lay out a square or 90 degree cut on narrow stock.

25. For boring and drilling round holes in stock;
    (a) Should the location dimensions be laid out by crossed center lines of the hole or by diameter layout measurements?
    (b) Should the size dimensions be specified by crossed center lines or by diameter measurement?

For each of the following questions check one answer only which most fully answers the question.

I Why are some drawings drawn to a reduced size scale?

(1) Because it is easier to draw. (1)
(2) Because the paper might not be large enough. (2)
(3) Because it shows a complete view of a large object within a close observation and yet retains the view in proportion to the size of the object. (3)✓ (3)
(4) Because a reduced size scale makes a more convenient drawing to handle. (4)✓ (0)

II Why are some drawings drawn to an enlarged size scale?

(1) Because it is easier to draw large than it is to draw small and intricate views. (1)✓ (0)
(2) Because small detail of objects can be more readily understood if drawn larger than actual size. (2)✓ (6)
(3) Because enlarged scale views are easy to see when a person is working fast in a shop. (3)

III Why should there be a difference in the size and darkness of object lines, and projection or dimension lines?
(1) So the object can be distinguished at a (1) glance by itself because of the heavy or darkened lines; then an observer can look more closely for detailed specifications.

(2) Dimension lines should be light so the dark arrow points and dimension figures will (2) be seen at a glance.

(3) Because 4H pencils make lighter lines than 2H pencils.

(4) Because projection lines are not retraced with softer pencils like object lines.

IV Why should orthographic projection be used in working drawings?

(1) So the various views can be drawn in less time.

(2) When the second and third views are not in orthographic projection the drawing (2) is as hard to read as a sentence would be if some words were written cross-wise with the line of writing.

(3) To show sides or planes that are adjacent to the first view of the object so they (3) continue the same adjacent or orthographic relationship.

(4) Orthographic projection shows adjacent (4) planes of an object in the most exacting arrangement for the clearest understanding of the object drawn.

V Visible object lines of orthographic projections are:

(1) To represent both the outline of the plane (1) in view and also the surface of the plane not in view.

(2) To represent the outline of a plane in view.

(3) To represent the surface of a plane not in view.

(4) To connect one projection view to another.

VI Layout for round holes in stock should be laid out by, and dimensioned from, center cross lines of the hole.
Why do we have Shop Work? Because Man is a "tool-using" animal. He is weak in himself and of small stature, stands insecurely on a base—-for the flattest footed, only about a half-square foot. He must straddle his legs lest the winds move him. Twice his own weight is a crushing load for him; a steer can toss him aloft like a bag.

But how can man control the forces of Nature? He can use tools, can devise tools. With these the mountain melts into dust before him; he kneads glowing iron as if it were soft bread dough; seas are his highway; winds and fire his untiring horses. Nowhere do you find him without tools; without them he is nothing; with them he is all.

Your beginning shop work will consist for the most part in the converting of raw materials into useful tools. By spending small sums of money during your beginning year, you will be able to make many tools and useful articles for yourself. You will accumulate a work kit of tools for use in the school shop and also at home. While in the shop, you will be required to wear some type of apron or work garment with pockets.
A study of the following pages will give you a brief idea of your beginning shop course. Did you ever have a friend come by when you made an article and ask, "Why didn't you make it out of this, or fasten it together with that?" And you had to answer, "I never thought of it." Careful planning will help you to avoid such mistakes. Instead, you should be able to answer with a definite reason why you PLANNED to construct in any certain way.

You should analyze your job and PLAN your work. Then you can determine why one way to construct or why one material would be better than another. By such a habit of PLANNING, you will make articles stronger and better. You will soon find that people will respect you as a dependable workman. Because of your study and thoroughness, your friends will begin to ask your advice.

For an inexperienced workman, even the simplest work should first have complete plans. The older and more experienced a workman becomes, the more plans he can retain in mind. He can make simple articles without much drawing and lay-out work. Also the
INTRODUCTION

experienced man has a memory stored with a rich supply of technical knowledge, "short kinks" in skills and information about shop work.

PLANNING shop work usually means drawing the article on paper. The drawing should show the kind of material, the number and sizes of parts, and the way joints are made and fastened together. These specifications for the job to be done belong on the drawing.

"Laying-out" is the part of planning which you do directly on the material. The "laying-out" is the marking on the material; such as pencil marks, knife point marks, punch marks, and marks made by many other "layout" tools. The "layout" marks show where your material is to be cut, where a bend is to be made, or where parts are to be fitted together.

The procedure for doing beginning shop work is: first, planning; second, laying-out; third, shaping material into usable shape; fourth, fastening parts together; and fifth, applying paint or some surface finish as desired.

In shaping material, CUTTING is your largest
problem. CUTTING usually takes more time and requires the most accuracy. Mistakes in CUTTING are the most difficult ones to correct. CUTTING calls for the keenest tools which require the most time to re-condition and are the most difficult to keep in condition. CUTTING is usually the most expensive operation in manufacturing because of labor, time, and cutting equipment.

Write answers to the following questions:

1. What enables a man to construct where other animals cannot?

2. What tools do you already own?

3. What tools would you like to own?

4. Name in order five steps which would be best to follow for most jobs of fabrication or construction.

5. For simple jobs, where does the experienced workman do much of his planning? The inexperienced workman?

6. Why are cutting tools the most difficult to keep in working condition?
PURPOSE

1. To provide a handy container for your small tools and note books.

2. To learn operations of squaring, sawing, boring and nailing.

PROCEDURE

1. Make a 3 view orthographic projection drawing to scale of the following tool box. Study, Douglass and Roberts, "Instruction and Information Units for Hand Woodworking", P. 17-22.

2. Note in the construction drawing on the next page that first there are two simple boxes drawn side by side and placed 1\(\frac{1}{2}\)" apart.
3. List all of the boards that are necessary to construct the entire box, this list is called the "Bill of Material." Study, Douglass and Roberts, "Instruction and Information for Hand Woodwork," P. 23-24.

4. Get your instructor's approval of your drawing and bill of material.

5. Furnish your own lumber if possible from used fruit crate lumber, this will save the expense of buying new lumber at school.
6. Measure and square your lumber; after studying any one of the following references,

Douglass & Roberts, "Instruction and Information Units in Hand Woodworking" P. 27-28.

Brown & Tustison, "Instructional Units in Hand Woodwork" P. 17-21.

Stanley Charts, Nos. 100 and 101.

7. Saw your lumber carefully just to your lay-out lines, but do not saw the lines. Study carefully, Douglass & Roberts, "Instruction and Information Units in Hand Woodworking", P. 29-32; or Brown & Tustison, "Instructional Units in Hand Woodwork" P. 33-38.

Note: It is very important that you take time to do your sawing very accurately. There will be no opportunity given to plane or smooth off a rough saw cut, as this is to prove your ability to run a saw and not a plane. You will have to hold up the weight of your saw on the thin lumber; otherwise it will tear the lumber roughly instead of leaving a clean-cut surface.

8. Lay out accurate center lines for boring holes for your handle in the partition boards.

9. Bore 1 inch holes with an auger bit, after studying Stanley Chart 117, and Brown and Tustison, "Instructional Units in Hand Woodwork" Unit 22.

10. Lay out straight lines between the holes and saw out the stock with your own keyhole saw which you will make; or else use a compass saw from the supply room. Refer to Douglass & Roberts, "Instruction and Information Units in Hand Woodworking" P. 30.
11. Use box nails for all joints. The general rule for selecting the length of nails is: the nail should be 3 times as long as the thickness of the first piece of lumber. Study, Douglas & Roberts, "Instruction and Information Units in Hand Woodworking" P. 148-154. Nail the box together by carefully choosing the location and spacing of your nails. Remember that a few nails well placed make a stronger joint than too many nails poorly placed. Do not put many nails through from the bottom into the end grain of the four end boards. End grain does not hold nails as strongly as side grain; therefore all good design should provide side grain for nailing to stand the principle strains of the structure.

12. Write brief answers to the questions from Douglas & Roberts, "Instruction and Information Units for Hand Woodworking" Pages 18, 22, 26, 28, 30, 48, 50, and 58.

13. After your question answers and work have been approved, have your Record Syllabus punched under lay-out work, sawing, boring, and nailing.
OBJECTIVE

1. To learn the "feel" under your hammer of steel that is in proper condition to forge.

2. To learn to form the "flow lines" or fibre of steel as compared to the fibre of wood.

3. To learn the "square" and "octagon" steps for tapering stock.

PROCEDURE

Note—Study the above OBJECTIVE, the following procedure and references before starting to work.

1. Forge a \( \frac{1}{4} \)" mild steel rod to a square taper.

2. Forge all tapered work at the far edge of the anvil.

3. Start with a yellow heat and strike with heavy blows.

Heavy blows while hot make a smooth, bulged end. Light blows and a poor heat cause a hollow end that will lap or split.

Refer to: "Forging", Bacon & Johnson, 70-71.

4. You must shape by striking on opposite sides and turning your stock back and forth on the anvil. Turning in one direction as you forge would twist your stock, separate the "flow line" fibre and cause it to split.

5. Forge fast in order to shape all that is possible from one heat.

6. Do not forge after you "feel" the soft dead sound change to a hard ringing sound.

7. Show your work from one heat to your instructor.

8. Cut off your tapered sample and save it.

9. Keep trying to forge a smooth taper from this $\frac{1}{8}$ stock with one heat. It should finish with a smooth plastic appearance and not appear brittle, glazed or with scale. You should have a round bulged shape at the point, about $\frac{1}{16}$" to $\frac{3}{32}$" square, and about $\frac{1}{8}$" taper.

10. Show each trial taper to your instructor. With his permission forge your square taper to a uniform octagon taper with one additional heat. Observe all the precautions of step #4.

11. When your instructor accepts the work of your octagon taper, secure a $\frac{5}{16}$" mild steel rod.

12. Perform the same procedure of steps 1 to 11 as with the $\frac{1}{4}$" stock. Continue to use a minimum number of heats and hammer blows.

13. When your work has been accepted secure a $\frac{3}{8}$" M.S. (mild steel) rod.

14. Repeat the same procedure as above. Taper about $2\frac{1}{4}$". Note that a good yellow heat is required and heavy accurate strokes.

15. After your octagon taper from $\frac{3}{8}$" stock has been accepted, reheat and form a smooth round taper following the precautions of steps # 4 and #9 without twisting or making the point jagged.
16. Present all your trials of work and your answers to the following questions for the instructor to check in your record syllabus.

Write the answers to the following questions after you have studied the Job Sheet and references and finished the Job.

1. Why should all tapered forging be done at the edge of the anvil?

2. What occurs to the steel if it is left to heat in the forge after a proper forging heat has been reached?

3. How may you avoid having a large amount of iron scale on your forging?

4. Why should a beginner at forging heat and hammer the least number of times possible?

5. What might cause the fibre flow lines to twist or split at the end of your forging?

6. Why should you cease with heavy hammer blows when the softness of your red heat is gone?
Iron has a fibrous grain structure quite similar to that of wood. This is caused by the process of manufacture when it is drawn out into commercial bars and rods ready for fabrication. After the hot molten iron is obtained from iron ore, it is poured into ingot molds. In these the liquid cools, crystalizes, and becomes solid. These cast ingots are then rolled or drawn out into bars or rods. This process of "drawing out" or "forging" into useful shapes affects the crystals and crystalizing lines. When the molten iron is cooled and crystalized, like water changing to ice, these crystal lines point in all directions. But the forging, drawing, and working of the metal when hot lays these crystal lines down straight so that they all lie parallel, pointing in one direction throughout the bar of iron. Small particles of impurities and slag that are in the cast ingot of iron make the iron porous. When the cast ingot is rolled out flat and drawn into bar shapes, it causes these porous slag particles to become elongated throughout the metal and iron and steel to have a fibrous structure.
Thus the forging process gives the metal a fibre structure.

This is why we say iron is similar to wood from a structural standpoint. In metal, these fibrous strands are called "flow lines". Flow lines must be taken advantage of if we are to fabricate metal for its greatest strength. To see these foregoing facts well pictured, study two paragraphs from Bacon & Johnson, "Forging", bottom of page 61 to bottom of 62.

You already know that when wood is bent into curved shapes it is much stronger than if it is cut to a curved shape from a flat board. The curved backs of some chair furniture furnish a good example. The greater strength of bent wood is due to the fact that the long fibre grain of the wood flows

Illustration of "flow lines" when openings are forged to shape. Here the flow lines are continuous and compact around the openings, which gives greater strength. Illustration of "flow lines" when openings are cut to shape.
continually through the curved part of the chair. The grain fibre has not been cut cross-wise to form the curve.

This comparison shows why we should always consider the flow lines when we fabricate metal. The presence of flow lines is the reason why when tools and metal parts are forged to shape, (meaning bent, hammered, or pressed) they are much stronger than if they were cut to shape. Do you understand now why a bar of metal that is bent to an angle, is stronger than if the same size article was cut to the angle from a flat plate of metal? Or do you understand why if a hole is made by punching and pushing the fibres to the sides of the hole it will leave the bar of metal stronger about the hole than if the hole had been cut out by drilling? Be sure to study the paragraphs from Bacon & Johnson and the pictures Figures 44 and 45 referred to above.

Write answers to the following questions:

1. What gives iron a long fibre structure which might be compared to the grain of wood?

2. Why does forging steel to shape leave it stronger than when it is cut to shape?
OBJECTIVE

1. To learn to recognize a neutral flame.

2. To learn the importance of maintaining a neutral flame.

INFORMATION

I. The Nature of Fire

Fire is caused by chemical action. Oxygen from the air unites with the combined hydrogen and carbon of the fuel you use, and the result is combustion which gives you heat. No matter what you use for fuel—wood, coal, gasoline, acetylene gas, or dry gas—it contains some form of combined hydrogen and carbon. It is the chemical action with oxygen which gives you fire.

But, before we can have chemical action or fire we must first have a certain temperature or degree of heat in the elements we wish to burn. This is called the "Kindling Temperature". For example, if a 4" x 4" piece of wood were placed in an oven protected from an open flame, and the oven heated to the "Kindling Temperature" of wood, the wood would burst into flame. In other words, the degree of heat present would cause the chemical action of the fire to start between the oxygen in
the oven and the fuel in the wood.

In order to burn, a wood match must be heated to just as high a kindling temperature as a piece of stove wood. The only difference is that it takes less time to heat through a small piece of match wood. That is the reason we start burning small amounts of fuel to heat large amounts to their kindling temperature.

Different substances have different degrees of "Kindling Temperature". Iron has a much higher kindling temperature than wood. The phosphorus compound forming the head of the match has a much lower kindling temperature than wood. Therefore the friction heat produced by striking a match is sufficient to create the kindling temperature of the match head. This flame raises the match wood to its kindling temperature and makes it burn.

II FIRE EFFICIENCY

Fire may burn with a neutral flame, a rich carbon flame, or a lean oxygen flame. It depends on the chemical balance or the amounts in proportion of your fuel (hydro-carbon) and oxygen. Thus both the elements of combustion (fire) are
entirely consumed.

In an automobile or any other gas engine, the carburetor is a device which measures the correct amount of combined hydrogen and carbon of the fuel and the oxygen from the air. By this device the engine may be operated on a neutral flame.

A neutral flame is clean, free from any unused elements of combustion, and gives the best heat. Any overbalance or unused elements spoil the quality of iron or steel being heated.

A rich carbon flame is yellow and sluggish in nature. It gives black smoke and little heat. The excess carbon penetrates the hot metal, and in acetylene welding it makes the metal brittle and weak.

A lean oxygen flame is extremely transparent, harsh, and noisy. The excess oxygen "burns out" the metal, leaves it coarse grained, scaled, brittle, and weak. No matter what type of outfit you are using to make heat, LEARN TO OPERATE IT WITH A NEUTRAL FLAME.

PROCEDURE

1. Secure a Bunsen Burner and a scrap of wire.
2. Close the air intake openings.

3. Open a small amount of gas and light the burner flame.

4. From what you learned of the above information under FIRE EFFICIENCY, make various adjustments between the fuel and oxygen and note the variety of flames.

5. Adjust a rich, carbonizing flame, and notice how easily you can pass your finder through it. Notice how poorly it heats a wire.

6. Adjust a lean, oxidizing flame, and notice the efficiency for heating the wire.

7. Adjust a neutral heat flame and hold a wire just above the tip of the flame. Then slowly move the wire downward through the flame until it reaches the burner. Notice that different parts of the neutral flame produce different degrees of heat.

8. (Note) When you use a coal forge, a gas forge, a soldering furnace, or an Oxygen -Acetylene Welding torch, you apply identically the same principles of adjustment to maintain a neutral flame.

Write answers to the following questions after performing the above procedure:

1. What are the important chemical elements that make a wood fire?
2. What important chemical elements combust to make many of the common flames?

3. What causes the chemical action of fire to first start?

4. Explain the meaning of "Kindling Temperature."

5. What would happen to any fuel if it were brought to its kindling temperature away from any open flame?

6. Which has the lower kindling temperature, a small piece or a large piece of the same kind of wood?

7. Describe the effect of using a carbonizing flame on steel.

8. Describe the effect of using an oxidizing flame on steel.

9. Describe the effect of using a neutral flame on steel.

10. How can you recognize a carbonizing flame?

11. How can you recognize an oxidizing flame?

12. How can you recognize a neutral flame?

13. Where is the hottest part of a neutral flame?

14. Where is the coolest part of a neutral flame?
If wood is in a green, sap, or willow-like condition, or if it is thoroughly steamed, it can be formed by bending and compressing. When the wood fibre or grain structure is in this moist condition, it can slip and form to the shape desired by a workman. If the wood were dry and hard, it would split, crack, or break.

Iron and steel must also have their flow lines and grain structure made loose and slippery if they are to be bent, hammered, and formed (forged) to shape. Otherwise such forming would strain or fracture the structure of the metal. You may make the grain of your metal slippery and plastic if you heat it slowly throughout its thickness. The heat necessary to allow this relaxed grain structure is known as the "Critical Temperature" of steel, which is about 1350 degrees. You may judge this critical temperature by using a magnet. While you apply heat to your iron or steel, test it every few moments, as the heat rises, for the pull of a magnet. As soon as the magnet fails to pull or attract, then your metal has passed its "critical temperature". Above this temperature, the grains of your steel are
free to slip into various positions as your hammering (forging) may determine.

Now a question should arise in your mind--. How much hotter than this critical temperature can you have your metal without damaging it? When you raise the temperature hotter than the critical point, the fine grains of steel in their relaxed condition begin to break apart and these particles reunite to form larger grains. Thus the grain size will continue to grow as long as you continue to raise the temperature. This is called "grain growth" of steel. It weakens your steel.

The only way grain growth can be refined again is by careful forging. A skilled workman can manipulate his blows while the steel is loosing its heat, so that the grain will become refined. But he must stop his hammering as soon as the steel has cooled to the critical temperature. Any blows given below the critical temperature will cause structural stress and strain in the grains and flow lines of your iron. This will produce a tendency to split, crack, or break, similar to the effect of hammering or bending dry wood.
The critical temperature is one of the most important factors to keep in mind. The grain size is finer at this temperature than at any other time. Steel is the strongest when it has the finest grain and when free from any internal strains. Metal should be heated only enough to make it soft to forge easily. Heat always in a neutral flame, and never forge metal after the heat is lost beyond a dull red color. Always finish your forging by giving the last few blows on the flat sides to "pat down" those flow lines parallel for greater strength.

Write answers to the following questions:

1. Under what condition can iron be hammered without damaging its strength.

2. What is the most important condition of steel at the critical temperature?

3. What detrimental condition occurs in steel when it is heated very much hotter than the critical temperature?

4. How can a coarse grain condition in steel be refined?

5. How does proper forging at the correct temperature make steel stronger than before?
OBJECTIVE

1. To learn to appreciate the ownership of fine tools.
2. To learn how to use and care for files.

INFORMATION

1. NAMES OF FILES

Sometimes files are named according to their shapes, for example, a knife file.

Sometimes files are named according to their use, for example, saw file, hand file, and a mill file.

2. SHAPES OF FILE TEETH

"Single Cut" files have teeth cut in only one direction. This gives a long cutting edge.

"Double Cut" files have teeth cut in two directions. This gives short pointed teeth.

3. SIZE OF FILE TEETH

In their order of size they vary as follows:

1. RASP
2. COARSE
3. BASTARD ("go between" a COARSE and SECOND CUT)
4. SECOND CUT
5. SMOOTH
6. DEAD SMOOTH

Years ago machinists started heavy cuts with a "coarse" file, smoothed off with the "second cut" file, and finished with the "smooth" file. They found too much difference in tooth size from a "coarse" down to a "second cut", so manufacturers added the "go between" or better known as the "bastard". The "rasp" and "dead smooth" were added for extreme types of use.
4. LENGTH OF FILES

The length of the body is always given in inches without the tang.

HOW TO USE:

1. Stamp your initials on the SOFT blue tang of your file.

2. Before attempting to use a file, make a simple wood handle.

3. Never touch a file against steel that has been hardened. And NEVER apply pressure on the back or "clearance" side of the teeth. A file is expensive and will do good work indefinitely when its proper use is known; but it may be ignorantly ruined in a few minutes.

4. Always stroke the FULL LENGTH of a file, and NOT the middle section only. Never allow a file to side slip in filing.

5. For fast cutting or cutting through crust or scale, always use the pointed tooth "double cut" file and with either the coarse or bastard size teeth.

6. Always file by cutting against the "rake side" or cutting edge of the teeth. NEVER ALLOW PRESSURE against the "clearance side" or the cutting edge.

7. Examine a "single cut" file and notice the shearing or slicing action of the long cutting edge. This "slicing" cut for finished work may be still further increased by "draw filing" with a "single cut" file. "Draw filing" is done by holding your file cross-wise between your hands and cross-wise with your direction of motion. But, again, always apply pressure against the "rake side" of the teeth, as in straight filing, and NEVER against the "clearance" side. When either draw filing or straight filing, cutting backwards ruins the file teeth.
8. Files never "pin-up" or cut rough unless too much pressure has been applied. Always arrange to file on the largest surface, thus contacting as many teeth as possible. In this way excessive pressure is less likely to occur.

9. Clean a file by forcing the end grain of wood along the teeth. Use a prick point to remove the tightest pinnings. This is better for the file than a wire brush.

In addition to the above, study also E. Perry Van Leuven, "Cold Metal Work" P. 21-27; Harry A. Jones, "Machine Shop Practice" P. 12-15; Simonds Saw & Steel Co., "File Facts".

Write answers to the following questions:

1. List in a sensible order the four things in describing a file that you should tell a hardware store clerk when purchasing any file.

2. List the above 4 things specifically for some specific file.

3. Compare the hardness of the two parts of a file.

4. Why not file hardened steel?

5. What is the difference between filing against the "rake" side or "clearnace" side of file teeth?

6. Give two reasons why you should stroke the full length of a file.

7. When should you use a "double cut" file and when a "single cut" file?

8. What difference does it make as to which direction of stroke you apply the pressure?

9. "Draw filing" is done ONLY with what shaped teeth?

10. What is the difference in filing action between "draw filing" and "straight filing"?
11. What causes a file to side slip either when straight filing or draw filing, and how may it be prevented?

12. What two things should be considered for preventing a file from "pinning-up"?

13.a What do the mechanics who are particular about their tools have against using wire brushes for cleaning files?

13.b What precaution does he take in carrying files loosely with other tools?
OBJECTIVE

1. To give added practice in the three objectives of Job Sheet No. 3.

2. To learn the difference between steel that is mild in carbon (mild steel) and steel that is high in carbon (tool steel).

3. To learn the value of ownership and paying for useful material.

PROCEDURE

I Forging for shape.

1. Secure a piece of octagon tool steel that contains about .80 carbon (which means only 80/100 per cent). Secure a size octagon 3/8" by 4", which will cost you about 40¢ per pound.

2. Stamp your initials with 1/8" steel letter stamps about 1" from the head end of what will be your punch.

3. With only one forging heat, forge the head end to a slight octagon taper. Do the usual tapering steps of first square, then octagon, and then round.

4. Forge the bit end to an octagon tapered point about 2½" long. Use not more than two heats if possible. Use all the care as in Instruction Sheet No. 30 to produce a smooth, plastic appearing texture to your forging.

5. Have your work approved by your instructor.

II Annealing.

Anneal any stress that you may have hammered into your forging by referring to E. Schwarzkopf, "Plain and Ornamental Forging", P. 134, and by doing the
following steps.

1. Secure a magnet.

2. Heat the tapered bit end very slowly by a low flame and withdraw it frequently to test the pull with the magnet at a point about \( \frac{3}{4} \)" from the end.

3. Stop heating as soon as you do not feel the pull of the magnet, or with the first dull red.

4. Cover your forging instantly with lime dust to make it cool as slowly as possible. This requires about 30 minutes, or you may leave it covered until your next period.

III Preparing a neat finish before hardening.

1. File the tapered bit end smooth by draw filing.

2. File two slight nicks on opposite sides near the point.

Do not file the original black oxidized surface of the octagon steel.


3. Have your work approved by your instructor.

IV Hardening

Harden the bit end of your punch by referring to Lynn C. Jones, "Forging & Smithing" P. 94-96, and by doing the following steps.

1. Secure a quench can of clean, cool water.

2. Heat the bit end very slowly in a low flame as for annealing.

3. Obtain the critical temperature (the heat where the magnet first ceases to pull) just above the file nicks.

4. Quench by plunging the entire punch into the clean,
cool water and moving it about in the water until the entire punch is cold.

5. Find out what part of your punch was made hard by test filing along the bit end with the corner of an OLD file. Check with your instructor.

V Polishing and Testing

1. Secure a No. 80 grain strip emery cloth. A strip 18" long will cost you 5¢ and may be used many times in your shop work.

2. Polish the tapered bit end with the emery cloth.

3. Break off the tip at the filed nicks and check the grain quality of your forging with your instructor. If the grain shows too much growth it must be refined. Refer to: Lynn C. Jones, "Forging & Smithing" P. 142, and Forging Information Sheet No. 15.

VI Tempering

Temper or "soften the bit from its hard brittleness to a temper strong and resilient enough for its use.

Study references: "Metal-Work", Harry A. Jones, P. 70; Forging Information Sheet No. 17, and the following steps.

1. Secure clean cold water.

2. Heat over a small flame, either from a Bunsen Burner or soldering furnace. Hold the shank over the flame, never the bit end, and turn your tool
other side up a couple of times to heat more evenly.

3. Watch for appearance of oxide heat colors. Keep flame on the shank only. The heat conducts throughout the steel, and as the steel increases in heat, the iron oxide forming on the surface changes color.

4. When the bit end shows a brownish light purple, quench the entire tool instantly until completely cold.

CAUTION: It is important that you decide your tempering heat from the first range of oxide colors that appear. You will notice after the first range of colors appear near the flame more series of similar colors also appear. These later colors are from a greater heat which would give far too soft a temper for your tool.

5. After you have learned the proper shape from Ernst Schwarzkopf, "Plain and Ornamental Forging" P. 147, get your instructor's O.K. to grind the bit.

Write answers to the following:

1. Explain the most important things you should try to accomplish while forging steel to shape which will help to produce a strong forging.

2. Explain the purpose of annealing and in what condition it leaves the metal.

3. Explain the purpose of hardening and how it leaves the metal.

4. Explain some important precautions to follow while hardening.

5. What parts of a punch should be hard?

6a. Should the head end be hard or soft?
6b Why?

7. Explain two methods by which you may know when your steel has raised to the "critical temperature" of heat.

8. How is it possible to harden only part of a piece of steel and not all of it?

9. Why should you remove the scale from hardened steel with emery instead of a file?

10. What causes a large grain growth in steel?

11. How may a large grain growth be refined?

12. What does tempering do to steel?

13. What determines how much you should temper?

14. Of the six major steps of procedure listed in this job sheet, name in the order of performance the four that are most fundamental for forging and heat-treating carbon steel.
PURPOSE

1. To learn the "square step" in forging all flat tapers.

2. To gain practice in the plastic "feel" of proper forging heats.

3. To learn to form the "flow lines" to give added strength to flat tapers.

PROCEDURE

1. Use either \( \frac{1}{2} \)" square or \( \frac{3}{8} \)" round M.S. (mild steel, meaning steel that contains a very mild amount of carbon.)

2. Forge to a square taper \( \frac{1}{4} \)" square at the point and taper \( \frac{1}{2} \)" long. Practice the steps and precautions gained from the Job Sheet, "Feel of Hot Iron".

3. Reheat and forge only from the two flat sides. In this manner form a flat taper without striking on the edges.

Note: Forging to a flat shape without striking on the edges is extremely important where maximum strength is required, such as in the making of tools. The "flow lines" of the steel formed by flat forging might be compared to the straws of a flat whisk broom. They are straight and parallel when neatly flattened from two sides, but if the broom is pressed edgewise the straws
lap crosswise with each other. A similar condition occurs when the flow lines of steel are hammered edgewise; and a "fracture" of steel might take place under extreme strain. Refer to Bacon & Johnson, "Forging" P.

PRECAUTION

When you forge to a flat shape the edges bulge and become slightly rounded and irregular. It is a temptation to hammer out these edges straight, but DON'T. If it were to be a finished tool made of carbon steel, the edges could be ground and filed to a neat shape.

4. Have your work checked by your instructor.

5. Cut your flat taper from your bar by using the hardie. Refer to Ernst Schwarzkopf, "Plain and Ornamental Forging" P. 34 and Fig. 35.

6. Try to harden this taper of mild steel as you did your center punch of carbon steel.

7. Get your instructor's approval of your work and your Record Syllabus punched.

Write answers to the following questions:

1. How may a thin taper of mild steel be forged without striking the hammer against the anvil face?

2. When forging a flat taper, why should it be forged square during the first half of the reducing process?

3. Why should the last forging on a flat taper be done only on the flat sides and never on the edges?

4. How should steel be cut on the hardie to prevent the hard face of your hammer from damaging the edge of the hardie?

5. Explain two factors that help to produce a clean, smooth forging free from scale and without a rough, pitted surface.
The chief difference between iron and steel is that steel contains carbon. It is carbon combined with iron in the grains of steel that make it much stronger, and possible to harden by heat treating. Plain iron and "mild steel" cannot be hardened by heat treatment. Mild steel is steel with only a mild or slight amount of carbon. To learn the proportions of carbon used in common steels for tools, see section 65, pages 142-144, by Schwarzkopf "Plain and Ornamental Forging".

Carbon steel is often called "tool steel". If it is heated through thoroughly at the critical temperature when it is in its most refined grain condition, and if it is instantly cooled such as by being quenched in water, it will retain this refined grain. Such cooling also hardens it to an extreme hardness and leaves the steel at its best structure. The hardness, however, leaves it so brittle that for most uses, it must be softened or tempered. Oil quenches do produce less hardness and brittleness than do water quenches. Therefore, for some uses, oil quenching does not require further softening or
Steel is softened or tempered according to the use intended for the tool thus heat treated. The tempering or softening, however, does not change the fine quality of grain structure achieved by the sudden cooling at the critical temperature. The tempering process is well explained by Lynn C. Jones, "Forging and Smithing" P. 97. For plain iron or mild steel there is no way of keeping the fine grain structure which is present only at the "critical temperature".

"Safety" from personal injury is important to consider as you go about your work. Are your hammer handles strong? Are your hammer heads tight? Are your hammer faces smooth of battered chips? Is the work space about you clean and orderly that you will not stumble, slip, or fall?

Write answers to the following questions:

1. When should an iron metal properly be called a steel?

2. What can be done to steel, that contains carbon, which cannot be done to iron, without carbon?

3. What various proportions of carbon should steel contain for making the following tools?
(a) cold chisels and punches
(b) drills and countersinks for drilling in steel
(c) screw drivers and pliers
(d) hammers
(e) hack saw blades

4. How can carbon steel be hardened?

5. What does "tempering" of steel mean?

6. How can carbon steel be tempered?
To Learn -
1. Planning & Sketching.
2. Accurate Filing.

Use of a Bradawl -
To start small holes for wood screws and nails. The sharp square corners of this blade design make it handy to roam a hole large, yet the narrow end taper leaves only a small hole if desired.

Material -
Carbon steel drill rod stock 1/8" x 3".
Wood dowel stock about 1/2" or 3/4" dia.

To Proceed -

1. File the bit end to square shape for 1 1/4".

2. File this bit end to a square taper 1/16" square at the end and tapered 1/2" in length.

3. File the 1/2" square taper to a flat taper, but file on two opposite corners making a flat chisel edge diagonally across the 1/16" square end.

4. File the tang end to a square pointed taper 1 1/4" long.


6. Cut a handle from wood dowel or other suitable round stock.

7. Drill a 1/8" hole 1/2" deep in handle, then increase the depth with 3/32" or 1/16" drill.

8. Hold the bit in vise and drive the wood handle on the tang end.

9. Test the hardness of the bit end by a flat side pressure of 10 lbs. against the scales at 30° angle with horizontal. It should not bend or break by this test.
PURPOSE

To gain practice in the forging and heat treatment of carbon steel.

PROCEDURE

1. Decide what size cold chisel you want to make, with your instructor's approval.

2. Proceed with your work by following the three sources of information:

   (a) Instruction Sheet No. 39, Shaping a Flat Taper.
   (b) Lynn C. Jones, "Forging and Smithing" P. 141-142.
   (c) Instruction Sheet No. 37, Center Punch.

PRECAUTION

Do not break off your grain size sample until after your instructor has approved your tempering operation. Consult the temperature color chart at the round table for the proper temper.

3. You may wait to grind your chisel until you make your tool grinding gauge.

Write answers to the following questions:

1. What is the reason for annealing a forging?

2. What part of a finished chisel should be left soft? Why?

3. What is the reason for hardening your chisel?

4. What is the reason for tempering your chisel?

5. What determines how much any steel should be tempered?

6. Name in the proper order of performance the four major steps in forging and heat treating carbon steel.
TOOL GRINDING GAGE

GAGE FOR:
- TWIST DRILL
- COUNTERSINK
- COLD CHISEL
- CENTER PUNCH
- WOOD CHISEL
- PLANE IRON
- CENTER DRILL

Wased Union High School
Wasco, California

Designed by Paul H. Moore
Drawn by Richard Jones
Hold your drill back of the gage for 12° lip clearance.

Center punch 82° cone.

Hold your chisel back of the gage for 12° lip clearance.

Wood chisel one bevel at 30°.

Hold drill below gage for 18° lip angle.

Plane iron one bevel at 30°.

Hold your countersink below gage for 62° lip angle.
OBJECTIVE

1. To learn the proper shape for grinding cutting tools.
2. To lay out work by degrees with a bevel protractor.
3. To saw and file up to, but yet leave the lay out lines.
4. To learn how to make a tight joint by riveting.

PROCEDURE

1. Secure 1 piece of cold rolled steel 1/8"x 1"x 2 5/8".
2. Stamp your initials on one end.
3. Square the ends neatly to finish 2 1/2" long.
4. With your scribe and a square, lay out the intersecting lines to locate the vertex of each angle, as shown at left. Refer to Harry A. Jones, "Metal Work", P. 26-29.


Note: For the 12 degree bevel, first set the
blade parallel or "o" with the protractor and then swing it to 12 degrees from parallel. For the other three angles, first set the protractor blade at 90 degrees or perpendicular to the protractor, and then swing it toward either side to an amount equal to one half the total number degrees of the angle you are laying out.

6. Saw out the notches, being careful not to cut your layout lines.

7. Finish by carefully filing closer to your lines with a knife file, but never cut your lines.

8. Secure a midget hack saw from the supply room and saw a very light saw kerf at the vertex of each angle.

9. Test all of your angles with the templates hanging on the blue print and model chart at the round table.

10. Stamp the degree figures at each angle.

Note: Discontinue working at your tool gauge at this step and do not finish the remaining steps until you are assigned to do so in the Second Series of Jobs.

11. Make the handle as per blue print, and refer to E. Perry Van Leuven, "Cold Metal Work", P. 35-39.

12. Lay out your rivet holes as per blue print and center punch for them.

13. Drill for one rivet through both pieces and drop the rivet in place with the two parts in the assembled position.

14. While holding the assembly with one rivet in place drill through both parts at once for the other rivet. Be careful that the head is held square across the stem while drilling the last hole.

15. With your countersink sharpened and approved, countersink the rivet holes slightly on the outside of the stem.
16. Place your rivet set in the vise, assemble the parts with both rivets in place and hold in place on the rivet set with one rivet at a time. Cut the rivet flush with the countersink side, draw the two parts tight together and rivet with not more than 2 or 3 hard hammer blows. Any additional blows tend to make the rivets brittle and loose. Refer to Harry A. Jones, "Metal Work" P. 30, 32, 33.

17. Have your work approved and recorded.

Write answers to the following questions:

1. How may rivet heads be left neat and round?

2. How may a rivet joint be made snug and tight instead of loose?

3. Why should a rivet be placed in the first rivet hole of a rivet joint before the remainder of the holes are drilled?
PROCEDURE

1. Secure a round piece of 1.10 carbon steel \(\frac{1}{4}\)"x 9" from the supply room.

2. Forge a large square taper to about 5/32" square at the end. Two heats should forge a screw driver complete.

3. Forge to a long flat taper to a thin end.

4. Follow the usual practice of annealing, filing and nicking the end. Be sure that your blade is filed flat with a uniform thickness for about \(\frac{1}{4}\)" above the file nick. Gauge this thickness to fit edgewise into a No. 5 screw head slot.

5. Get your instructor's approval to harden.

6. Temper after consulting the temperature color chart.

7. Have your grain size sample checked.

8. Sharpen your screw driver bit after studying the reference for sharpening screw drivers found in your record syllabus.

9. Have your record syllabus punched.

Note: You may fit the handle of your screw driver after you finish the first series of bench work jobs.

Write answers to the following questions:

1. What shape should a screw driver be forged first in drawing the taper? Why?

2. Why should all filing for the finished thickness be done before hardening?

3. Explain the proper shape to sharpen a screw driver.
CHARACTERISTICS OF CUTTING TOOLS

Why is it that you can use one material to cut another material, or that you can even use it to cut another piece of the same material? For example, a piece from a bar of carbon steel may be made into a chisel which will cut the original bar of steel. The secret is, that the two pieces must have a difference in hardness. A harder material with a properly shaped edge will cut a softer material.

Soft or very fibrous materials should be cut with a keen edged tool, a tool have a small "angle of keenness". Materials that are very hard or brittle should be cut with a blunt edged tool, a tool having a large "angle of keenness."

Cutting edges need an "angle of clearance" where they contact the material to be cut. Consider the "angle of clearance" and also the "angle of rake" in the use of a garden hoe. Hold a keen edged hoe with the handle high and pull it through the surface of the earth. Your hoe has a small "angle of clearance" and a large "angle of rake". This small angle of clearance makes a slicing cut which cuts easily and
Beginning Shop Information Sheet No. 52

CHARACTERISTICS OF CUTTING TOOLS

Sheet 2 of 7

"RAKE ANGLE" "CLEARANCE ANGLE"
EARTH SURFACE

and pull. Notice that you have a large "angle of clearance" and a smaller "angle of rake." Your cutting edge contact is blunt and makes a scraping cut instead of a slicing cut. The material being cut does not "rake" of the blade easily. The cutting edge dulls sooner.

Keen edged tools cut best with a small "angle of clearance" from the surface of the material and with a large "angle of rake" in the forward direction.

Blunt edged tools also cut best with a small
from the surface of the material. But their large "angle of keenness" leaves only a small and rather poor "angle of rake." Therefore, cutting edges that have a large angle of keenness do not make such a slicing cut, nor do they "rake" off smooth slices or shavings.

Can you examine a cutting tool and know for certain if it is sharp? It is the very EDGE of a tool that does the cutting. Look at the edge on the side of a cross cut saw tooth. This edge slices across the wood grain.

Look at the cutting edge that is across the bottom of a rip saw tooth. This tooth chisels also across the grain of wood as it rips. A rip tooth edge edge extends between two "points" or corners, and therefore
the teeth of a rip saw and of a cross cut saw both cut across the wood grain. Metal saws cut on the bottom edge of the tooth like a wood rip saw or also like a "single cut" file. In either case the CUTTING EDGE all the way to the very corner of the tooth must be sharp for saws to cut well.

Notice the small "angle of rake" and the large "angle of clearance" and also the large "angle of keenness" on a saw tooth. Compare the edge of a saw tooth to the edge of a plane bit. The edge of a plane bit has a smaller "angle of keenness", a small "angle of clearance" and a large angle of rake".
CHARACTERISTICS OF CUTTING TOOLS

Sheet 5 of 7

Beginning Shop Information Sheet No. 52

Do you understand why a saw leaves a rough cut and a plane a smooth cut? Examine very carefully the teeth of a file. A "single cut" file cuts with a long cutting edge, and a "double cut" file cuts with tiny short edges converging to points. Do you see that the cutting edges of both files have an "angle of keenness", "angle of clearance" and "angle of rake"? Do you understand that ANY file cuts with only the forward movement? Cutting edges of ALL tools should be relieved from their material during BACKWARD MOVEMENT. Cutting edges dull more quickly when they are NOT cutting than when cutting if they are in contact with their material.
and "angle of clearance."

Two important things to learn about sharpening and using cutting tools are:

I. The USE as to-
   1. The hardness or softness of the material that is to be cut.
   2. The smoothness you expect to produce on the surface of the material.

II. The SHAPE as to-
   1. The proper "angle of keenness".
   2. The proper "angle of clearance".
   3. The proper "angle of rake".

Write the answers to the following questions:

1. What is the first condition necessary to enable one piece of material to be used to cut another?

2. What is the important difference between the shape of cutting edges shaped to cut soft material and those shaped to cut hard material?

3. What is the difference in the cutting effect between cutting with a large or small angle of rake?

4. What is the difference in the cutting effect between cutting with a large or small angle of clearance?

5. What is the difference in the use of tools having a large or small angle of keenness?

6. What is the difference between the cutting edges of a single cut and a double cut file?

7. How large should be the angle of keenness of each of the following tools; (1) pocket knife, (2) plane iron, (3) wood chisel, (4) cold chisel, (5) saw teeth? (Study references from your Record Syllabus)
under "Tool Sharpening").

8. Should the actual tooth cutting edges of cross-cut saws cut across the wood grain or parallel with the grain?

8b .................rip saws?

9. What is the difference in cutting angles that causes planes to produce smoother surfaces than saws?

10. Should cutting edges be in contact with the work during the forward or backward movement?
APPENDIX D

THE SHOP REFERENCE LIBRARY

A LIST OF BOOKS AND INFORMATIONAL MATERIALS
USED BY SHOP STUDENTS IN PURSUIT OF
THE SUGGESTED PROGRAM


<table>
<thead>
<tr>
<th>No.</th>
<th>Author</th>
<th>Title</th>
<th>Publisher</th>
<th>Location</th>
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<tr>
<td>90</td>
<td>South Bend Lathe Works</td>
<td>How to Run a Lathe</td>
<td>South Bend Lathe Works, South Bend, Indiana</td>
<td>1930</td>
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<tr>
<td>92</td>
<td>Thatcher, Edward</td>
<td>Making Tin Can Toys</td>
<td>J. P. Lippincott Co.</td>
<td>Philadelphia</td>
<td>1919</td>
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<td>93</td>
<td>Trew, Marion S. and Bird, Verne A.</td>
<td>Sheet-Metal Work</td>
<td>The Manual Arts Press</td>
<td>Peoria</td>
<td>1923</td>
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<td>95</td>
<td>Tustison, F. E. and Kranzusch, Ray F.</td>
<td>Metalwork Essentials</td>
<td>The Bruce Publishing Co.</td>
<td>Milwaukee</td>
<td>1936</td>
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<td>99</td>
<td>Walker-Turner Co., Inc.</td>
<td>Bench Saw Jointer and Shaper</td>
<td>Walker Turner Co.</td>
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<td>100</td>
<td>Welch, R. L.</td>
<td>Elements of Sheet Metal Work</td>
<td>The Bruce Publishing Co.</td>
<td>Milwaukee</td>
<td>1926</td>
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