EDUCATION FOR THE FOUNDRY INDUSTRY

EDUCATION FOR THE FOUNDRY INDUSTRY

By

JOHN H. SHEPLEY

Bachelor of Science

Millersville State Teachers College

Millersville, Pennsylvania

1948

Submitted to the Department of

Industrial Arts Education and Engineering Shopwork

Oklahoma Agricultural and Mechanical College

In Partial Fulfillment of the Requirements

For the Degree of

MASTER OF SCIENCE

1949

OKLAHOMA
AGRICULTURAL & MECHANICAL COLLEGE
LIBRARY
NOV 3 1949

ACKNOWLEDGEMENTS

The writer is indeed glad to acknowledge his indebtedness and express his gratitude and appreciation to Dr. DeWitt Hunt, Head of Industrial Arts Education and Engineering Shopwork, Oklahoma Agricultural and Mechanical College, Stillwater, Oklahoma, for his educational leadership, valuable suggestions, and kindly criticisms so generously given on this thesis. Acknowledgement is also made to Associate Professor E. D. Soderstrom, Associate Professor of Industrial Arts Education and Engineering Shops, Oklahoma Agricultural and Mechanical College, and Mr. George K. Dreher, Executive Director, Foundry Educational Foundation, Cleveland, Ohio, for their helpful suggestions and criticisms.

Gratitude is also extended to my wife, Alma Shepley, for her help, inspiration, and encouragement throughout the preparation of this thesis.

J. H. S.

240298

APPROVED BY:

Thesis Adviser and Head, School of
Industrial Arts Education
and Engineering Shopwork

Associate Professor, School of
Industrial Arts Education
and Engineering Shopwork

Dean, Oklahoma Institute of
Technology

Dean, Graduate School

TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

CHAPTER I

PURPOSES AND TECHNIQUES

The important position that foundry practice, as an edcational subject, is achieving in the educational programs of our public schools, trade schools, technical schools, colleges and universities of today is causing more emphasis to be placed upon it. Engineering colleges, technical institutions, trade and public schools of this country are almost universally making it an integral part of their educational system.

The type of training offered in the foundry programs meets the vocational and industrial need of many average types of communities throughout the nation. The fact that foundry practice provides an opportunity for the excerise of the creative urge in terms of material things and partially meets some of the experience required by the foundry industry has caused it to become a part of the curriculums of many institutions of learning. The instructors in this field are realizing the possibilities that are offered for those who are interested in foundry practice and the materials involved and are constantly initiating improvements on the old techniques and establishing programs that will keep abreast with the constantly changing machine world.

The types of communities that are being served by foundry practice are growing to be unlimited. The many agricultural areas that exist throughout the country have institutions that offer courses in foundry practice, although there does not exist an immediate industry for the application of the techniques taught.

This study was made through the desire to determine the extent to which foundry practice is being taught in the various institutions of learning. The writer made an extensive search for information concerning foundry practice being taught in public schools, trade schools, technical schools, apprentice training programs, colleges, and universities in the United States.

__How the Problem Originated__. The expansion of the foundry industry and the need of competent personnel influenced the writer into inquiring as to what education is being offered in public schools, trade schools, technical schools, colleges and universities to fulfill the demands of the foundry industry. The lack of written information concerning foundry practice in the institutions mentioned was the second incentive promoting the need for this problem to be solved. It is apparent that educational institutions are failing to train sufficient students to fill the vacancies in the foundry industry, that have been left by retiring foundrymen. The machine operating personnel can be replaced by a training program devised to familiarize untrained workers with the functions and operations of foundry machines. The technical and management vacancies need college trained personnel, although some have been filled by the workers with a number of years experience. The Foundry Educational

Foundation has developed an educational program, which has been adopted by five leading engineering institutions of the United States, to train young men to fill the vacant positions. The graduates of these institutions are few in number compared to the vast number of positions vacant in the foundry industry.

The engineering colleges and technical institutions with some revision in their curriculums could amply supply the foundry industry with sufficiently trained personnel to fill the vacancies in the managerial and technical departments.

The teacher training institutions with the aid of an industrial arts department could train teachers to acquaint public school students with some of the fundamental operations and processes involved in foundry work. This training and information that the industrial arts teacher should present to students would reduce the amount of time that industry would have to consume to train the worker before efficient production can be maintained.

Statement of the Problem. Many studies have resulted from a felt need or an interest of some person in a particular study. The various phases of foundry practice that are being taught in some educational institutions was an incentive for carrying out this plan. The writer feels that administrators might become better acquainted with the needs of the foundry industry and how they can be satisfied, through this study and better realize its importance to the educational curriculums. The outcome of this study is planned to be the beginning of proposed programs of study concerning foundry practice for public schools, trade schools, technical schools, and engineering colleges. This study is proposed to give the reader some information concerning the need of Education For The Foundry Industry.

The Purpose to be Realized from this Study. This study will serve the purpose of meeting the tenative needs of the foundry industry, through the training of students in such programs devised by administrators familiar with foundry operations. This study should help clarify the thinking of those who are in doubt as to the importance of foundry practice in the educational programs. The writer recognizes a need for a special program of foundry practices that would meet the present need of the foundry industry.

Delimitations. When a study is undertaken, certain boundaries and limitations should be established so that definitions may aid in the development of the subject. This study has both educational and industrial limitations. Only education that will aid a student in acquiring information about or to gain employment in the foundry industry will be considered. The foundry industry will be the only industry involved in this study. The foundry practice programs of a number of educational institutions were surveyed and analyzed. The results of this study will aid the writer in the proposing of a foundry practice course for public school industrial arts departments that will meet the approval of the Foundry Educational Foundation.

Definition of Terms. Throughout this study certain terms are used in regard to foundry practice and quite often in such ways that formal definitions of them would prove helpful. The definitions given are by recognized authors in the foundry industry, in industrial arts teaching, in vocational education or by men of considerable experience in these fields.

> Vocational Education, as contemplated in the national vocational education act, includes education and training of less than college grade, the specific purpose of which is to equip boys and girls, men and women for the effective pursuit of occupations. Such training prepares those of school age for advantageous entrance into skilled trades and occupations. (39, page 29)

> Founding. The art of preparing molds from plastic materials of such nature as will successfully resist the intense heat of molten metal, as loam or sand, in which may be formed the object to be produced in metal, the process being completed when the metal has been melted, run into the mold, and permitted to solidify. (8, page 1)

> Foundry. An establishment in which molds are made and metal melted to pour them, for the production of marketable castings. (27, page 550)

> Castings. Articles made by pouring molten metal into a mold and allowing it to solidify. (40, page 167)

> Ferrous Castings. Casted articles whose basic ingredients are iron and carbon. Other elements are always present but their effect on the physical properties of the casting is usually secondary to the mixture of iron and carbon. (44, page 51)

Non-ferrous Castings. Non-ferrous castings are those composed of metals, or alloys, in which there is little or no iron. Until recently, the copper alloys formed the bulk of this non-ferrous group. Aluminum alloys have been developed by the demand for light-weight material for automobile and airplane parts. (35, page 180)

Ornamental Foundry Work. The art of preparing molds of a highly figured nature to be used for display, such as; statues, plaques, plates, panels, and jewelery. (8, page 295)

Pig Iron. The product of the blast furnace, or any other process for reducing iron ore to iron rich in carbon, cast into convient shapes for easy handling. This shaped mass of iron and carbon are called 'pigs'. Pig iron is known as either 'sand-cast' or 'machine-cast'. (27, page 245)

Cast Iron. An iron containing so much carbon that it is not usefully malleable at any temperature. The dividing line between steel and cast iron is taken at 2.00 per cent total carbon. The practical range of total carbon in cast iron is from 2.50 to 4.00 per cent. (27, page 548)

Cire Perdu. Cire perdu the French term for the 'lost wax method'. The process wherein the article to be cast is first modeled in wax; the wax model being then enclosed in plastic clay, upon heating which the wax melts and runs out, leaving the mold. (8, page 2)

Industrial Arts. A study of the changes man makes in materials to increase their values to meet needs, of the appropriate usage of products made, and of the social advantages and problems resulting from the making of these changes and products. (10, pages 1 and 2)

Apprentice Training. Apprentice training is any systematic training in the all-round practice of any given trade including regular advancement in shop operations together with regular instruction in those subjects which will sustain interest in

> the performance of these trade operations, broaden the technical knowledge of the apprentice, and lay the foundations for sound progressive trade practices. (6, page 3)

> Engineer. A general term used to designate one who pursues a branch of professional engineering. Specifically designated as Chemical Engineer; Civil Engineer; Electrical Engineer; Industrial Engineer; and Mechanical Engineer. (41, page 329)

Research Methods Used in this Study. The material that is used in this thesis was obtained by the library technique and documentary evidence through correspondence. The material presented in the second chapter was obtained exclusively through the library technique. The library technique was also used in obtaining much of the information about the institutions of higher learning offering courses in foundry practice. Due to the lack of publications concerning the need of educated and trained workers in the foundry industry, the writer sent letters, requesting this information, to prominent national organizations of the foundry industry. The writer reviewed all similar studies that could be found which might offer suggestions toward this study.

Since the purposes and techniques regarding this study have been stated, the next chapter will make a study of the history of the casting process.

CHAPTER II

EVOLUTION OF THE CASTING PROCESS

Archaeologists and historians have been unable to establish sufficient evidence to determine the exact time that founding work was started. Explorers and investigators have found in the ruins and burial grounds of the Egyptians metal ornaments that were cast by the "Lost Wax Process". The year 5,000 was estimated as the year the ornaments were cast, but this is just an approximation.

Tubal Cain. The first recorded history indicates that Tubal Cain, who was seven generations from Adam, was a "master in every kind of bronze and iron work" also "the forger of every cutting instrument of brass and iron". Tubal Cain is recognized in literature as one of the earliest workers in iron. (27, page 2)

Aristotle B.C. 322. According to Aristotle, who wrote in the fourth century B.C., cast iron as well as steel was known in his time: "Wrought iron itself may be cast so as to be a liquid and to harden again; and thus it is they are wont to make steel". Aristotle mentions and describes the process for making Indian steel called "wootz", which was made in crucibles. (16, page 23)

England B.C. 200. Bars of iron were used as currency in England during the period known as La Tenae, that is the second century B.C. (16, page 24)

Japan 70 A.D. There are records of a bridge with cast iron chains being built in Japan in the year 70 A.D. From about this time cast iron seems to have become a lost art until about the eleventh century. (27, page 3)

Eleventh and Twelfth Centuries. During the two hundred years of the eleventh and twelfth centuries an Anglo-Saxon monk, named Theophilus, in his "Diversarum Artium Schedula" described every possible process that could be employed in making and ornamenting elaborate pieces of ecclesiastical plate. Among the processes mentioned was that of casting. This writer is quite obscure and is known only through his own few writings. (16, page 30)

Pig-iron 1311. The first recorded example of pig-iron dates back to 1311.A.D., in the Siegerland of Westphalia. Knowledge of the subject must have spread widely, in spite of the secrecy then prevailing, and probably through the medium of journeymen furnace operatives; for we hear that castings were made in Sussex about forty years later. Pig-iron was made by running molten metal into open-sand molds, having the shape like a sow with a litter of suckling pigs, and thus recieved its name, "Pig-iron". (27, page 3)

Memmingen, England 1388. Cannon were being produced for several years, but stones were used for shot. Cannon balls were first cast in the year 1388, in Memmingen, England. The iron workers of this time found that the molten metal from the furnaces, when cooled and fractured, would have a gray appearance, and would appear granular in structure. Cannon, cannon balls and stove plates were the main products of the iron worker. (27, page 4)

Grave Slab 1450. Mark Anthony Lower, secretary of the Sussex Archaeological Society, mentions a specimen of cast iron in Great Britain from the fifteenth century, a cast iron slab in Burwash Church, Sussex, with a ornamental cross and inscription; "Pray for the soul of Joan Collins", indicating that cast iron was then in common use in England. (16, page 36)

Richard Moldenke, a prominent foundryman and author, located a rare book in the Armory of Berlin. The rarity of the book was of great concern to Richard Moldenke and he quoted several paragraphs from this rare book in his publication, The Principles of Iron Founding. The book in the Armory of Berlin is of great importance, for it links the accomplishments of the past with present day activities in the founding trades. The quoted paragraph that follows should give the reader a slight impression of the importance of the rare book.

> The famous Armory of Berlin contains a copy of a rare early book on smelting, dated 1454, in which there is described the making of molten iron in the hearth furnace, the metal being run into well baked and highly heated loam molds. Arsenic, antimony, and tin were used in small quantities an alloying additions to render the metal fluid. This book describes another furnace the hearth of which was used for stacking up alternate layers of wrought iron and charcoal, which gave a molten

> iron---thus corresponding to the previously mentioned crucible-made recarburized iron. The interesting portion of the description is that this furnace had above the hearth a chimney terminating in a 'Kuppel' for better charging purposes. This was probably at the first rather short and resembling a small tub without a bottom. It may thus be connected up with the Latin diminutive cupula, of cupa a tub; and eventually became 'cupola', 'cubilot' and 'Kupelofen', respectively, in English, French, and German. (27, page 4)

England, 1500. The first evidences of the art of heavy castings of iron were recorded in England before the turn of the fifteenth century. Shortly after the turn of the century, i.e. 1516, a five ton gun called the "Basilicus" was cast in London. Godefrois de Bichs, of Liege, Belgium, established the first iron "foundry" in England. The "foundry" was established in Dartford, in the year 1580. Forty years before this two cast guns were brought from Ireland. (27, page 5)

Neuhutte in Germany, 1592. Stove plates and oven plates were cast in sand beds, the face of the plates were figured by the use of wood cuts as patterns. The most famous plates were cast in Neuhutte, Germany, the face of the plates had figures portraying the Resurrection. (27, page 9)

Brede Fournes, England 1636. Ironmaster Richard Lennard, cast some very fine stove plate, at Brede Fournes, England in 1636. Several of the plates portrayed the Ironmaster holding his sledge, with a weighted mold and ladle at his feet. The plate also contained the coat of arms of the Ironmaster. (27, page 11)

Lynn, Massachusetts 1644. A cast iron cauldron is the first household utensil to have been cast in America. The cauldron was made at the Saugus Iron Works, Lynn, Massachusetts, in the year 1644. The capacity of the cauldron is slightly less than one quart, it weighs two pounds, thirteen ounces. The dimensions of the cauldron, which is round in shape, are four and one-half inches wide and four and one-half inches deep. (16, page 45)

Reaumur of France, 1721. The first recorded evidence of cupola melting in Europe points to Reaumur, these records are dated in 1721. Reaumur had a little portable cupola sixteen to twenty-four inches high and six to nine inches in diameter. He published the results of his experiments carried on by microscopic studies of the structure of various cast irons. He graded pig iron into ten grades, according to composition and content of silicon, sulphur and phosphorus. These ten grades were substantially the same as those used today. Reaumur understood the value of gray iron for foundry work, and recognized the tendency of gray iron to become white iron with reheating.

There is record of several portable cupolas being operated in Europe. The owners and workers would travel from village to village making pots, kettles, cauldrons, flatirons and and-irons from the wrought iron scrap they could gather in the villages. (27, page 16)

Christopher Polhammer, Sweden, 1750. Christopher Pol-

hammer, a Sweedish engineer, and the Henry Ford of his day, had recognized the economic advantages of applying machines to industry by using an elaborate division of labor. In Polhammer's plant at Stiernsund, Sweden, water power was used in making tools, household apparatus and agricultural implements. Among the machines invented were those for cutting teeth in wheels for clocks, for hammering pans and plates out of tin-plated iron sheets, for drawing deep cups and vessels out of tin plate, for making nails, a shearing mill for cutting bars, heavy rolls for sheet and band iron, and power machinery for polishing rolls for the rolling mill. Sweden thus became the center for the production of finished and partly finished nails, of the type now known as "cut nails". Due to his skill in building a light rolling mill, Polhammer led in the production of rolled bars, plates and sheets. Polhammer's developments required additional knowledge in iron founding, both as to size and intricacy of parts. Thus in Sweden, as in Holland, France and England, the iron founder was constantly challenged to produce bigger and more elaborate parts.
(8, page 8)

New York City 1798. A water reservoir made of cast iron was erected, by the Aaron Burr Water Company in the year 1798. After the reservoir was taken down in 1845 and the parts inspected, it was found that the metal was just as good as the day it was erected. The Astor House was connected to the water line coming from the reservoir, until the Croton supply became available in 1845. (27, page 18)

Manchester, Connecticut, 1801. A "fireproof" cotton mill was built in Manchester, the floors of which were carried on cast iron columns and beams. This was the first mill of its type, but was later remodeled due to the experiments of Hodgkinson. The experiments of Hodgkinson were commenced in 1824. These experiments have been the basis of all designs for cast iron beams and columns up to the present time. (36, page 505)

The Steam Engine and the Iron Founding Industry, 1820. In 1820, James Watt of Greenock, England began making improvements on the steam engine, invented by Newcomen, in 1769. After 1820, the improved steam engine was in great demand by all industries. The demand for the steam engine marked a new epoch in the founding industry, and the activity which ensued resulted in the establishment of many iron foundries. The development of iron and steel shipbuilding resulted in the establishing of active and progressive works in iron founding in the Midlands, on the northeast coast of England. In Scotland the iron foundries maintained a high reputation for the production of all types of iron castings. (9, page 3) (29, page 6)

Thomas Tredgold 1822. "A Practical Essay on the Strength of Cast Iron and Other Metals", was published by Thomas Tredgold an English civil engineer of Brandon, England. (16, page 98)

South Boston Iron Company 1827. The South Boston Iron Company was established by Cyrus Alger in 1827. The plant was originally known as the "Alger Iron Works". Cyrus Alger had been working in the production of cast iron ordnance since 1809. He made the first rifled cannon in 1834, the first "malleable iron" gun in 1836, and in 1842 he made the twelve inch "Columbaid". (27, page 5)

France, England, 1850 to 1860. Cast iron girders and columns were in general use by 1860 in England for supporting floors of mills, factories, workshops, and public halls. The details of cast iron columns and floors in the United States followed English practice.

The Halles Centrales of Paris was erected in 1854. This structure was composed of a series of pavilions. The pavilions were built of cast iron columns and cast iron arches. (36, page 507)

The Capitol Building, Washington, D.C. 1865. The capitol building is one of the best known American structure using cast iron for columns, arches, lintels, decorative wall panels, and girders. The dome of the capitol has several cast iron panels which aid in supporting the outer masonry wall. The capitol was completed in 1865. The use of cast iron in building construction was quite common about this time, in the United States and throughout Europe. (36, page 508)

Thomas D. West, 1882. Thomas D. West of Cleveland, Ohio published articles on foundry practice in 1882. He also wrote numerous books concerning foundry practice. West is responsible for developing a system of standard samples of cast iron borings for interchange and checking of chemical determinations. Officials in the United States Bureau of Standards took charge of the standard samples, shortly before the death of the founder. (27, page 19)

Founding Grows in the United States. A tremendous development in metal manufacturing and metal founding was experienced in the United States during the nineteenth and twentieth centuries. Most of the great ore deposits have been discovered within the past hundred years. Metallurgists have developed scientific control of the quality of metal and have made possible its production at extremely low-price.

The vast expansion in the foundry industry was due to two factors, the first of which was, increasing mastery of the science of founding, of patternmaking, of molding, of melting and pouring and of annealing and finishing. And second, the increase in machine-tool skills resulted in a greater demand for castings. The foundry in other words, is the child of the Machine Age.

CHAPTER III

INDUSTRIAL ARTS COURSES AND THE FOUNDRY INDUSTRY

Education is one of the oldest institutions responding to human needs. Its main purpose has been to prepare one for the duties of life. An insight into the modern industries of today reveals some of the results of education. This insight is gained by offering courses on elementary foundry practice in junior or senior high schools. This type of education is referred to as industrial arts, which includes studies concerned with many of the educational activities of modern industry.

The casting process is one of the most depended upon manufacturing processes in this modern machine age. The techniques and skills involved in the casting process were kept in secrecy until the Industrial Revolution in the Eighteenth Century opened the way for the expansion of the casting industries. Following the Industrial Revolution the techniques and skills of the casting process were no longer kept in secrecy, but were being taught in public institutions, to those individuals who desired to make the casting industries their life's work. The industrial arts curriculums of the public schools are continuing to teach some of the fundamental techniques and skills that represent the basic practices and fundamental processes of current industrial activities.

<u>The Purpose of this Chapter</u>. The purpose of this chapter is to acquaint the reader with methods that are followed in

the industrial arts curriculum, in preparing students to work at foundry jobs, and in acquainting the students with some of the fundamental operations concerning foundry practive. It is a fact that the industrial arts program usually has a series of shop work activities available for the introducing of skills and techniques of a variety of occupations and industrial processes. Foundry work should always be included in these programs of activities.

The attaining of industrial arts objectives through foundry practice will be discussed along with the correlation of foundry practice courses with other industrial arts and academic subjects. A foundry course is proposed as Part B of this chapter, with the attaining of the objectives in mind.

PART A

INDUSTRIAL ARTS OBJECTIVES

Dr. Louis V. Newkirk, a prominent leader in the field of industrial arts, lists eight objectives in his book, The Industrial Arts Program. They are quoted as follows:

1. Develop the ability to plan and complete projects, using a variety of tools and construction materials in a workman like manner.
2. Give experiences that will increase understanding of modern industry and that will lay the foundation for and help determine vocational interests.
3. Develop the ability to read and make working drawing, charts, and graphs.
4. Develop the ability to recognize quality

and design in the products of industry.

5. Develop the ability to maintain and service in a safe and efficient manner the common products of industry.

6. Provide an objective medium for expression in mathematics, science, language, arts, and social science.

7. Develop an interest in crafts as a valuable medium for creative expression in leisure time.

8. Give experience that will develop social understanding and the ability to work effectively with others either as a leader or as a member of the group. (23, pages 7 to 13)

Attaining the Industrial Arts Objectives. The industrial arts objectives, that were devised by Dr. Louis V. Newkirk, can be achieved through foundry practice. The writer will discuss how these objectives can be realized through foundry practice. The objectives will be discussed in the order they were stated.

The First Objective. Develop the ability to plan and complete projects, using a variety of tools and construction materials in a workmanlike manner. This objective can be attained through the planning of how a pattern can be most efficiently cast. The student will use molding tools that are common to the craftsmen in the foundry industries, such as the slick, bellows, trowel, riddles and drawing pins. The use of the proper grade of sand for the project to be made is an important factor for a good casting. The procedure that should be followed in the ramming of the mold must be carefully planned before the work is started.

The Second Objective. Give experience that will increase understanding of modern industry and that will lay the foundation for and help determine vocational interests. A list of projects can be devised that will require varied operations for the student to perform. The simplest pattern will require operations that are in constant use in the foundry industries. The aptitude and dexterity that the student demonstrates in making the simple projects can be a basis for determining vocational interest.

The Third Objective. Develop the ability to read and make working drawings, charts and graphs. The student will be confronted with sketches and drawings to help explain a process or procedure. The student should be encouraged to do some designing. This will require the student to make drawings that are understandable and meaningful to others. Charts and graphs are used to show the various phases that metal passes through while melting.

The Fourth Objective. Develop the ability to recognize quality and design in the products of industry. This objective can be attained by the comparing of various castings according to the use and the design of each. The ability to determine good or bad castings can be developed by the inspection of various castings by the students, followed by discussion to show the good and bad features of the castings. Men from the foundry industry should be invited to talk to the students about the products they produce.

The Fifth Objective. Develop the ability to maintain and service in a safe and efficient manner the common products of industry. This objective can be best attained through the use of visual aids, such as motion pictures, to demonstrate how various castings should be used, and how they might be serviced by the different welding methods.

The Sixth Objective. Provide an objective medium for expression in mathematics, science, language, arts, and social science. To attain this objective the student should be required to estimate the cost of material used for his projects. Science is constantly used in the making of a project such as; the distribution of moisture through the sand, the melting of the metal, pouring of the metal, and the cooling of the metal. The correct foundry terms should be learned and used while the student is in the shop. The best example of the misuse of terms is that of the average student calling foundry sand dirt. A visit to a local foundry will encourage the students to use terms appropriate for the work they are doing. The instructor can introduce the historical background of the casting process and have the students discuss their everyday life without the casting industries. This discussion will show the students the importance of the casting industries.

The Seventh Objective. Develop an interest in crafts as *a valuable medium for creative expression in leisure time.* The personnel organization in the individual shops will contribute to the achieving of this objective to a great degree.

Foundry Practice and other Industrial Arts Subjects. Foundry practice can be fitted into the industrial arts program, without affecting adversely the other industrial arts subjects. Other industrial arts subjects will correlate well with foundry practice. The drawing classes will aid the student taking foundry practice when he wants to design a casting. The foundry will yield castings that will need to be machined, this machine work will be of greater interest to the students than the usual excerise work commonly found in high school machine shops. The woodworking shop will serve as a place where the students can make patterns that they would like to cast in the foundry.

The students making projects in the foundry, will not only use the knowledge they recieved from the industrial arts classes, but will use knowledge from their mathematics, science, geography and history classes. The amount of knowledge used from these various classes will depend upon how well the foundry lessons are prepared by the teacher. There should be sufficient projects of interest on hand for the students to work with. The simplest projects will require operations that are performed by workers in the foundry industries.

Tools and Equipment for an Industrial Arts Foundry. The foundry can be one of the most inexpensive shops of the school.

The majority of the tools and equipment can be made in the other shops by the students. The number of tools to be purchased will be few. The following tools are those that will probably be purchased; slicks, lifters, bellows, riddles, trowels and water bulbs. The tools that can be made in other shops are; rammers, rapping bars, strike-off bars, drawing pins and gate cutters. These shop made tools can be made in the wood, machine, and sheet metal shop.

The equipment for the foundry such as, flasks, bottom and mold boards, sprue pins, risers, melting furnace, and molding benches can be either purchased or made in the shops. The writer suggests that the foundry should have a few good metal flasks and at least one snap flask, so the students will get some experience in using the same equipment as is used in the foundry industries. There are several grades of sand that can be used in the school foundry. The selection of the sand will be a matter of the choice of the teacher.

PART B

PROPOSED COURSE OUTLINE FOR FOUNDRY WORK

The following course outline for foundry work is proposed for use in the junior or senior high school general industrial arts shop. In the following outline "A" in each unit of instruction indicates the manipulative work to be performed, "B" designates the accompanying informational material, and part "C" suggests projects or exercises.

Unit 1. - Shop Organization

A. Students shall check equipment for the foundry units.

B. Methods of procedure to be followed in the foundry shop, the development and characteristics of the working material, such as; aluminum, lead, type metal and bronze, can be discussed.

C. Checking of types of castings used in the industrial arts shop.

Unit 2. - Making a Pattern With Hand Tools

A. Forming proper draft on a simple pattern with a plane, try square, and other hand tools.

B. Specifications for pattern making.

C. Select or design a pattern.

Unit 3. - Use of Machinery in Pattern Making

A. The student will have learned the general uses of the machines in a previous woodworking course. He will now learn the method of cutting the proper draft with a jig saw or band saw and a wood turning lathe.

B. Technical terms applied to pattern making and foundry work.

C. Turn a pattern for a gear blank or a pulley on a wood turning lathe.

Unit 4. - Preparation of Sand for Molding

A. Dampening, cutting, and riddling of molding sand.

B. Selection of molding sand.

C. Prepare sand for ramming.

Unit 5. - <u>Ramming a Mold</u>

A. Ramming a mold, removing the pattern, and repairing torn surfaces.

B. Types and uses of molding tools.

C. Make a mold for a flat back pattern.

Unit 6. - <u>Melting and Casting Aluminum, Lead and Type Metal</u>

A. Using flux for aluminum. Correct pouring temperatures of aluminum, lead and type metal.

B. Safe practices in foundry work.

C. Cast flat back casting or other project of which a mold has been made.

Unit 7. - <u>Finishing</u>

A. Removing gates and cleaning casting.

B. Files and abrasives for finishing aluminum, lead, and type metal.

C. Give project desired finish.

Unit 8. - <u>Making Core Boxes and Cores</u>

A. Making cylindrical forms.

B. Composition of core sand.

C. Ram cylindrical core for grinder base.

Unit 9. - <u>Making a Casting with Cored Cavities</u>

A. Making a mold with cored cavities, setting cores, pouring molten metal, and cleaning cavity after metal is poured and set.

B. Permeability of molds for non-ferrous metal castings. Identification of metals.

C. Cast grinder base.

Recommended Textbooks. A single basic textbook is recommended for this course. Sufficient numbers of the adopted text should be available in the shop so that there is at least one book for each two students. The following textbooks are recommended as satisfactory for this course.

1. Lewis, Melvin S., and Dillon, John R., Instruction Sheets for the General Shop Foundry, McGraw-Hill Book Company, New York, 1932, 77 pages.

2. Richards, William Henry, Principles of Pattern and Foundry Practice, McGraw-Hill Book Company, New York, 1930, 121 pages.

3. Smith, Robert E., Units in Patternmaking and Founding, The McCormick-Mathers Publishing Company, Wichita, Kansas, 1939, 72 pages.

4. Stimson, William C., Gray, Burton L. and Grennan, John, Foundry Work, American Technical Society, Chicago, 1939, 214 pages.

EQUIPMENT AND MATERIALS REQUIRED FOR A FOUNDRY WORK AREA FOR FOUR STUDENTS

Specifications for Equipment. The list of foundry tools and equipment is given for aluminum which has a melting point of 1218 degrees Fahrenheit, this list will also apply to lead and type metal. The furnace and crucible or metal melting pot require no blower and can be constructed in the school shop. Most schools in Oklahoma have natural gas which may be used as the fuel for the melting furnace. Where this is not available, either oil or gasoline burning equipment may be secured for the furnace. The following list includes approved standard brands and the prices given represent the approximate cost of the equipment.

Quantity	Tools	Size	Retail Distributor	Price
1	Bellows	10"	Stevens	$ 3.00
4	Bench rammers	$3\frac{1}{2}$"x14"	Cast in shop (aluminum)	*
1	Bench rammer	$3\frac{1}{2}$"x14"	Made in shop (wood)	*
2	Bulb sponge	3/4 pint	Brodhead Garrett	2.70
4	Draw pins	1/8" dia.	Made in shop	*
4	Flasks	10"x14"x 20"	Stevens	31.60
1	Furnace	10 lb. Cap.	Made in shop (steel or cast iron)	*
4	Gate cutters	3"x4"	Made in shop (sheet metal)	*
4	Heart spoons	1"	Brodhead Garrett	2.40
1	Hub lifter	3/4"	Brodhead Garrett	.90
1	Metal pot	10 lb. Cap.	Made in shop (steel or cast iron)	*
4	Molding boards	1"x16"x 22"	Made in shop (wood shop)	*
1	Molding sand bin	1 barrel Cap.	Constructed of concrete	8,50
4	Muslin bags	1 lb. Cap.	Local	.80
2 ea.	Riddles	14 & 20 mesh	Stevens	8.00
4	Molders shovels	28"	Obermayer	6.00
2	Slick & Spoon	1 1/8"	Brodhead Garrett	1.40
1	Sprinkle can	1 gal.	Local	.75
8	Sprue pins	3/4" min. dia. x 10	Made in shop (wood)	*
4	Trowels	1 1/4"	Brodhead Garrett	4.00
1	Venturi tube	$\frac{1}{2}$" throat dia.	Made in shop (sheet metal)	*

Total cost of equipment for four students in foundry $70.05

* Metal or wood materials available at little or no cost.

Materials. A foundry unit costs relatively little. Materials needed for one semester are also comparatively inexpensive and limited in quantity.

Quantity	Materials	Size or Kind	Distributor	Price
1 bag	Core sand	50 lbs.	Stevens	$ 1.50
1 bag	Flour	10 lbs.	Local	.65
1 pkg.	Aluminum flux	4 lbs. Cryolite	Brodhead Garrett	1.00
1 pkg.	Parting compound	10 lbs.	Brodhead Garrett	.70
4 bags	Fine molding sand	125 lbs. No. 00	Stevens	15.00
200 lbs.	Scrap aluminum, lead or type metal		Local	14.00
Total cost of materials for foundry unit				$32.85

PART C

SUITABLE PROJECTS FOR THE INDUSTRIAL ARTS FOUNDRY

The selection of projects is a very important item in the industrial arts foundry. The projects should be of such design as to hold the interest of the student and must be rather simple to cast. The students will have to perform operations that are in common practice in the foundry industries although the pattern is of a rather simple design. The more complicated projects can be introduced after the students have acquainted themselves with the elementary operations required in the making of the elementary projects.

Flat Back Projects. It is recommended that flat back projects should be introduced at the beginning of the students experiences in foundry practice. The amount of difficulty that the students will encounter will be slight, for the irregular surfaces will only be on one side of the pattern, which can be put in the drag section of the mold. The following can be classified as flat back patterns; ash trays, book ends, doorstops, and door knockers.

Split Pattern Projects. Projects requiring a split pattern should not be introduced until the student has secured good results with the flat back patterns. The teacher should give reasons for some patterns having more than one piece when introducing the split pattern for the first time. Some projects requiring split patterns are; candle-stick holders, reading lamps, handles for knives, handles for screw drivers, and finial ornaments for curtain rods. The split pattern type projects as just mentioned are not too difficult for the students to mold after a few weeks of simpler work. The operations involved are the same as those used in the foundry industries.

Irregular Parting Patterns. It is suggested that patterns requiring irregular partings should not be introduced to the students until they have mastered the molding of split pattern projects. The following are projects requiring an irregular parting; quoits, ink bottle holders, grinder guards and housings, cornbread pans, and spoked wheels. Instructions, either verbal or written should accompany each pattern requiring an irregular parting. The instructor should give a demonstration for each type of project and when students begin work on a new series of projects, instruction sheets should be issued to refresh the minds of the students.

Projects Requiring Cores. The students who adapt themselves to the foundry work will seek still more complicated projects to cast. Projects requiring cores will introduce another phase of foundry practice. Core making will hold the interest of the student after he is introduced to the needs and the functions of a core. Projects concerning machinery parts such as; cored pulleys, grinder bases, vise bases, and enlarger arms, are suitable to demonstrate the functions of cores.

Foundry practice should be introduced to students not later than the second year of their high school education. The students will then have sufficient time to decide if the foundry industry is a suitable industry for their employment. There will be enough of time for the student to change to trade education or make application for apprenticeship training. Local organizations of the foundry industry are interested in acquainting students with the practices of the foundry to such an extent that they are equipping foundry shops in high schools. The equipping of the Hackley Manual Training School in Muskegon, Michigan is a recent example of the interest that the foundry industry is showing.

CHAPTER IV

VOCATIONAL EDUCATION FOR THE FOUNDRY INDUSTRY

Every development in educational service is the product of many factors, some remote, others close at hand. Each emerging program has its antecedents in many fields, social, economic, technological, political. When the vocational schools came into prominence following the passing of the Smith-Hughes Act in 1917, their growth developed because of industrial, social and economic changes. Today we are faced with great interest in the development of vocational-technical training on the part of widely varied groups of industrialists, labor leaders, and educators. This interest has not developed out of thin air. It has come about because changes have occurred, which appear to warrant greatly increased emphasis on this aspect of education. The foundry industry has become one of the leading industries of the United States, thus being in demand for young men to fill the positions left by those retiring.

The Purpose of this Chapter. The writer wishes to arouse the interest of the reader to what vocational education is doing to help supply the foundry industry with semi-trained workers. The writer will attempt to show the error of the belief that the foundry is a place for those with a strong back and a weak mind, by considering the caliber of individual the foundry industry is seeking today. The skilled trades that constitute a major part of the foundry industry will be discussed, and attention will be called to the methods employed in the vocational schools in preparing youth for these skilled trades.

Need for Vocational Education in the Foundry Industry. At no other time than now has there been a greater demand for young workers in the foundry industry. The foundry industry has become a science, a science in which the diversified activities must be well coordinated in order to meet the demands placed upon them. The foundry industry has found it difficult to train sufficient men well enough to meet the changes that are constantly taking place in the modern mechanical world. The foundry industry has trained men for machine operating and repetitive operations. The leaders in the foundry industry have been compelled to rely on the vocational schools for the trained youth required to fill the vacancies in positions left on the retirement of skilled craftsmen. The vocational schools are preparing semi-skilled youth not only for the foundry industry but for many other skilled occupations of industry. The basic industries of the United States receive approximately five per cent of their skilled workers from the vocational schools. There are a variety of trades that the foundry industry is dependent upon, that is, within its own organization. A few of these trades will be discussed in the paragraphs to follow. The trades to be discussed are the five key trades of the foundry industry.

PART A

TRADES RELATED TO THE FOUNDRY INDUSTRY

There are many trades taught in the vocational schools that are directly related to the foundry industry. There are also numerous other trades that the foundry industry is dependent upon. The five basic trades directly related to the foundry industry are: (1) patternmaking, (2) core making, (3) molder, (4) cupola and furnace tending and (5) metal finishing. These trades mentioned are taught in vocational schools that are located in areas where the foundry industry is predominant.

Patternmaking. The patternmaking trade is composed of two classes of work, they are; wood and metal. The students in the vocational schools are first introduced to general wood construction such as, rough carpentry work, trim work, some cabinet construction and production methods. The student is permitted to make a selection of the type of wood working he wishes to make his life's work, after two years of the generalized wood working. Those selecting patternmaking are given related instructions and trade information along with suitable pattern work. In some places the students are given six to nine consecutive weeks of school work and then they go into industry for the same period of time as spent in the classroom. When the student becomes efficient in making wood patterns, he is given instructions in metal patternmaking. The time that the student spends in the class room and in industry is recognized toward apprenticeship training.

Core Making. The core making trade is not often thought of as a trade, but is classified as such by the United States Department of Labor. There are several vocational schools in the Greater Detroit area that teach core making. The core making trade ranks with patternmaking in the skills that are involved. The students following the core making trade spend the same amount of time in the classroom as they do in industry. The related instruction is given when the student is taking his classroom activities. The related material consists of; mathematics, physics, chemistry, blueprint reading, core sands and core binders. The uses of core making machines and ovens are considered of prime importance due to the fact that the students will be working in highly specialized shops, where production is the key word. Some of the students are employed in shops where a variety of cores are made, these shops are known as jobbing shops.

Molding. The molding trade consists of three definite types of molding operations. They are; (1) bench molding, (2) machine molding and (3) floor molding. The vocational schools, in areas where the foundry industry is predominant, teach all three types of molding. The students choosing molding as their life's work are often required to take a year of training in industry. The molder has to have a working knowledge of the patternmaking and core making trades. The related instructions are the same as those for core making except for the instruction on core making machines. Molding machines and sand handling equipment are studied to acquaint the student with the types of machines he will be working with once he enters industry. The vocational schools do not attempt to train skilled machine operators, industry and the student are left to decide as to the phase of molding the student will be the most profitable to industry and the student.

Cupola and Furnace Tending. The cupola and furnace tending trade is of marked importance. The vocational schools in the Detroit and Pittsburgh areas have special classes for those students interested in the occupation of operating a cupola or melting furnace. The related information is given in the classroom and practical experience is furnished by industry during the weeks the students are working there. The related information consists of; foundry sands, fire brick, and clay, care of the cupola and furnace, fluxs, fundamental metallurgy, determining charges, fuels, and the principles of ramming the bottom and breast of the cupola or furnace. Industry teaches the student, through observation and practice, the techniques of furnace and cupola tending. The vocational schools offering special instructions for this trade are few in number. The schools offering molding trade instruction include some instruction in cupola and furnace tending.

Metal Finishing. The metal finishing trade related to the foundry industry is of prime importance, for the saleability of the castings. This trade consists of; welding, chipping, grinding, sand blasting and heat treating. The related information is supplemented with the basic subjects such as; mathematics, science, physics and safety factors concerning the trade. Many of the vocational schools teach the students the fundamentals of welding separately and industry has to teach the student the remaining information and skills they want him to know.

PART B

PROPOSED COURSE OUTLINE FOR FOUNDRY WORK

The writer would like to propose the following course outline for those students interested in making foundry work their life's work. The outline is general in nature and the topics can be taught as the instructor sees the need for them. This outline will serve for basic and advanced foundry courses.

PROPOSED COURSE OUTLINE

Introduction

A. History of the casting process.

B. Place and importance in metalworking field.

C. Processing of casting metals from mine to foundry.

D. Foundry products.

E. Divisions of foundry work.

Foundry Tools, Equipment and Terminology

A. Care and use of machine and hand tools.

B. Types of equipment used in the production foundry.

C. Types of equipment used in the jobbing foundry.

D. The use of proper foundry terms.

<u>Patterns</u>

A. Types; loose, gated, boarded, split, cored and sweep.

B. Construction and color markings.

C. Storage methods.

<u>Foundry Sands</u>

A. Molding and core sands; grades, uses, binders, and mixes.

B. Sand handling and processing: machine and hand methods.

C. Sand testing: grading, moisture content, permeability, green and dry strength, refractoriness, and microscope study.

<u>Fundamental Principles of Molding</u>

A. Incorporation of tools and equipment to be used; sizes and types of flasks to be used, ramming, venting, gating, risers, chills, handling and floor planning, and shop symbols.

B. Sequential steps in molding course; flat back, coping partings, flat back with dry sand core, split patterns, 3 part patterns, bedding-in, printing back, sand match, cover cores, gated pattern, boarded patterns, sweep molding, and patterns, with number of cores requiring the use of chaplets.

C. Machine molding; squeezers, jolt squeezers, jolt roll-over, stripper (description), and sand slinger (description).

D. Molding-in; loam and pit molding.

Melting Theory, Operation and Equipment

A. Foundry fuels; coke, oil, gas, and electricity.

B. Cupola theory and operation; determining charge, bed, number of charges, proportion of materials, chemical reactions, volume of air, air resistence, temperature and melting rate.

C. Refractories and fluxes.

D. Nonferrous furnace operation; types of furnaces.

Metal Handling

A. Ladle lining and care of crucibles.

B. Mold pouring; principles involved, skimmers and strainers, gating according to shape and size of mold, gating to suit metal, gates on patterns, risers (size and location), feeding, and use of chills.

Coremaking

A. Sand preparation; mixes and bonding.

B. Sand handling.

C. Types of cores; green and dry sand cores.

D. Core reinforcing, venting, coatings and pasting, drying, and storage.

Cleaning and Inspecting Castings

A. Cleaning castings; tumbling, sandblasting, chipping and grinding.

B. Casting inspection; shrinks, cracks, surface texture, blow holes, sand holes, cold shuts, cored holes, and mismatches.

Safety and Good Shop Keeping

A. Sanitation; locker rooms, showers, drinking fountains, and lavatories.

B. First aid.

C. Care of tools, equipment, and materials.

D. Safety devices.

E. Personal attitude and dress.

Elements of Metallurgy

A. Chemical properties; sand and metal.

B. Physical properties; sand and metal.

Note: The foregoing course should be correlated with the drafting, pattern, and machine courses.

The vocational schools are preparing students to enter the foundry industry as semi-skilled workers or as apprentices. The students employed as semi-skilled workers are usually trained for some specific job, such as a molding machine operator or squeezer operator. Those students employed as apprentice molders will follow the standards of apprenticeship training devised by the company. The hours that the student has been in training in the vocational schools are often considered as part of the hours to be served as an apprentice.

CHAPTER V

APPRENTICESHIP EDUCATION FOR THE FOUNDRY INDUSTRY

Recognizing the obligation of the present generation in the foundry industry to supply the means for young men, who will be successors, to obtain training and education to fit them for their responsibilities, this outline of a standard apprenticeship plan for the foundry industry is made available. The standards suggested are a culmination of programs applied at various large industrial centers and represent the fruits of experience in foundries where sound apprentice training plans have been followed. The various features recommended are based upon the necessity for meeting the needs of various types of shops, engaged in a great variety of work and are offered as a basis upon which individual plans may be established.

The recommended standards do not include maximum requirements, as many foundries exceed the requirements in certain details, stressing those operations which require the most attention in their particular phases of foundry practice. The standards represent the conservative judgement of leading foundrymen concerning the essential factors in the development of a four-year foundry apprenticeship. Apprentice training programs have been started anew since World War II interrupted the programs by drafting the youth that had arrived at the age for apprenticeship training.

PART A

RECOMMENDED STANDARDS OF FOUR-YEAR FOUNDRY APPRENTICESHIP

The standards as presented are based upon the experience of members of the National Founders' Association and the American Foundrymen's Association, national organizations of the foundry industry, cooperating through a joint committee on apprentice training and foundry education. They are recommended to those foundries which plan the establishment of a training program with due recognition of the vital need of passing on to the new generation knowledge and skill to fit them for their tasks.

Management. The management should have a sincere conviction that apprentice training is necessary to the successful conduct of the business, and should be ready to act accordingly. Every foreman should be taught to share this view and understand that apprentices will require special consideration. Each foreman should realize that the boy of this generation is a new kind of boy, and should assume his part in the development of the youth from whom will come the leaders in a still more changed industrial age.

Selection of Apprentices. The selection of apprentices should be made in the light of some practical method for determining whether or not candidates for foundry apprenticeship are interested in foundry work. The age of boys should be not less than sixteen years at the time of entering upon their apprenticeship, and all boys selected should be physically capable of pursuing the trade. An eighth grade education, or its equivalent, should be required of all candidates. There is not a place in foundry apprenticeship for experimenting with subnormal boys.

Term of Apprenticeship. The term of apprenticeship for young men who have the equivalent of eighth grade schooling should be four years. The terms of young men with additional schooling should be shortened in proportion to the extent of the schooling. (20, page 18)

The period of apprenticeship may be shortened in certain communities where production shops with a limited variety of work predominate. Under these conditions there is no need to hold the apprentice for an additional year of training when the value of this additional training cannot be gained until he leaves the shop or the community, or both.

The terms of apprenticeship may be expressed in the indenture in periods of months, weeks or hours, as the employer may elect or as the law provides. Overtime work may or may not be included in the training period, depending upon the employer or the state law. As a general rule, the special stress of over-time periods is not conducive to good training.

Schedules of Advancement. Schedules of advancement in both work and pay for apprentices should be prepared in advance, and sincere effort should be made to hold to these schedules during the training period.

Schedules of advancement in the shop cannot be specified for every foundry; but in every case, apprentices should not be used for work which is ordinarily assigned to common laborers and which has no training value. The four-year schedule, however, should be divided between the major departments of foundry experience and related instruction.

The following training program was recommended by the Apprenticeship Committee of the Steel Foundry Society of America. With a forty hour work week, the program takes approximately four years to complete.

RECOMMENDED PROGRAM

Pattern storage and job layout .	300 hrs.
Sand mixing	200 "
Casting, cleaning and inspection	450 "
Furnace work	800 "
Bench cores	900 "
Squeezer molding	900 "
Bench molding	900 "
Jolt molding	1000 "
Floor molding	2870 "
Total	8320 hrs.

(12, page 42)

There will be foundries where one or more of these divisions are not available, in which case other work may be substituted which has equivalent training advantages. In some instances, it has been found advantageous to arrange for an exchange of apprentices with other foundries in order that each may give their apprentices a complete training.

The remaining portion of the apprenticeship course, will vary from six to twelve months in different foundry programs, should be spent on various operations such as the management believes to be in the interest of both training and plant economy. This may include additional work in the activities mentioned in the schedule, or mill room and inspection, sand testing, laboratory work and working in the shipping room.

Related Instruction. The related instruction should include at least four subjects; mathematics, drawing, science and economics, and related foundry technique. The proportion of time spent should be approximately as follows: mathematics, one year; drawing, one year; related foundry technique, two years. Classes should be held weekly and a one-hour class period is suggested for each academic subject and the time for related foundry techniques can be adjusted as needed. These academic subjects are being taught to apprentices, in the following companies; National Malleable and Steel Castings Company, Chicago; Dayton Malleable Iron Company, Dayton, Ohio; Lynchburg Foundry Company, Lynchburg, Virginia; and the Northern Malleable Iron Company, St. Paul, Minnesota. The companies mentioned have hired experienced teachers to teach the academic subjects to the apprentices. Some of the classes are held at night in a public school class rooms, other classes are held in provided areas within the plants.

Supervision. Supervision of apprentices is provided in the majority of foundries having apprenticeship programs. The supervision in the shops is the function of a special instructor or of departmental foreman or by selected assistant foreman. Class-room supervision is most effectively excerised by one trained in the technical practice of the foundry industry. The related information previously mentioned, is taught by experienced teachers having some knowledge of foundry practice.

PART B

GENERAL SUGGESTIONS

The program of apprentice training in the foundry must be carefully planned before the first boy is engaged, and this preparation will naturally attract attention. If the program of apprenticeship is based on a frank consideration of the company's need of apprentices and on what it can offer to attract the right kind of young men, then it can be expected that relatives of employees will make application as soon as they become aware of the intention of the employer to take on apprentices. Thus, a limited number of boys are ready when the program is begun, and it is generally considered that the start should be made with a small number.

Attracting Interest of Boys, Parents, and School Authorities. Information regarding apprentice training in the foundry must be placed before the public to attract additional young men of the required caliber, to create a favorable opinion and to encourage those who have already begun their course. In gaining public recognition of apprenticeship, cooperation with grade schools and high schools is of great importance, and apprentice supervisors and other industrialists will do well to become acquainted with principals and

and teachers. Talks before teacher and student groups and visits to plants by classes from the schools, are important factors in developing this cooperation.

Selecting Applicants for Apprenticeship. After apprenticeship has been established for some time and the plan of training has become known in the community, more boys will apply for training than can be engaged, and the problem then becomes one of selection. In considering an applicant for apprenticeship, it is most important to determine if he has the right motive in making application, that is, whether he is really looking for training in the trade or merely looking for work. The boy's adaptability for the kind of work that he wants to do can best be ascertained by trial period of actual work at the trade. For this reason, the first three months of apprentice training are ordinarily made a period of probation. In selecting applicants for apprentice training it is, of course, important to have information regarding his character, honesty, diligence, reliability and other qualities which are important in filling any position.

The Schedule of Advancement. The work schedule must specify the different operations and time to be spent at each, and is probably the most important part of the apprenticeship agreement. It should be the result of careful thought and planning by officials and instructors for weeks or months before the first apprentice is engaged. The schedule of work should be arranged so that it will give the apprentice opportunity to acquire skill in the trade in which he wishes to try his fortune. In planning the work schedule, it must be remembered that the ultimate aim of an apprentice course is to produce skilled mechanics who can take their places anywhere in the foundry industry.

Following the Schedule. It is not necessary or even possible to follow the schedule of work in the exact order in which it appeared in the agreement. Each apprentice must be worked into the various departments wherever and whenever he can be used effectively.

This part of apprentice supervision requires a constant adjustment between work schedules required by the agreement and the need for help in the various departments of the shop. In order to accomplish the work schedule, correct records must be kept of all work done.

The apprentice must naturally progress from easier to more difficult work in order to keep him always conscious of achievement and to make instruction easier. Confidence in the employer and interest and enthusiasm in the work will continue to influence the apprentice if he has constant evidence of concern on the part of the corporation to fulfill the contract requirements exactly.

Keeping Apprentices Interested in Work. The nature of young men is such that variety will maintain interest more than anything else. The older man prefers to remain at one kind of work; the young man seems to require frequent change.

The more variety of work which can be given to the apprentice, and the more frequently he can be changed from department to department within the requirements of the agreement, the more easily will his interest be maintained. It is understood, of course, that he must attain a certain degree of skill or each job, not necessarily perfection, before he is transferred.

Much can be accomplished by explaining the use of castings which the apprentice makes and by teaching him to follow up his work through the casting, cleaning and inspection processes in order to find his scrap and the reason for it. In this way, his work will become extremely fascinating to him and will challenge his ability and skill.

Cooperation with Foremen and Other Executives. The cooperative attitude of foremen and executives will be improved by an earnest attempt to adapt the training program to production requirements, insofar as this can be done without sacrifacing its efficiency. It is well for the supervisor to remember always that the apprenticeship program is a service to the shop organization, and that it is important to adjust transfers of apprentices and other changes to the conditions of work in the plant. An advisory committee of superintendents or foremen on apprentice training has been of great value.

Interesting Apprentices in School Work. Sometimes boys who are genuinely interested in their trade do not appreciate the importance of school work. With intelligent effort this attitude may be changed. Apprentices should be taught that a trade is a combination of knowledge and manual skill, and that shop work alone will impart only the manual skill, leaving the apprentice ignorant of the theoretical side of his trade and only partly equipped for his work.

Class work can be made interesting by means of concrete and specific rather than abstract instruction. Examples and illustrations having reference to the trade work should be constantly used. A record of grades and school work should be kept for each student in connection with a record of his shop work and the improvement or retrogression should be pointed out from month to month. The value of these grades will be increased if a report of them is sent regularly to the parents or guardians.

Planning Lessons for School. School work, as well as shop work, will need to be planned carefully in advance. The lessons should be laid out so as to cover completely the entire field of instruction which the apprentice course requires. Lesson material has been prepared by various associations and agencies interested in apprentice training and, if there is a local vocational school, first class service in this direction may be expected from its authorities. This in no way decreases the need for cooperation between school and shop in adapting material to the peculiar requirements of local conditions.

The school instructor must prepare for each class meeting as well as for the entire program. Nothing distracts so much from the effectiveness of school work as hesitation and faltering on the part of the teacher. Whatever form of lesson plan used, it should clearly indicate the trade work to which each part of instruction is related. Practical shop illustrations and examples should be used.

Individual instruction is essential so that each student may progress at his own natural rate. Each boy has his own peculiarities, his own mental habits, and instruction must be adjusted to all of them. Some students will require special assistance; other will made rapid progress and may be given assignments in addition to the regular course.

The First Class Meeting. The first class meeting should be given over largely to building up anticipation of an interest in the course of studies to be followed by means of a graphic description of the work to be done and the benefits to be derived from it. These benefits must be honestly stated in concrete terms. Stories with direct application to the work are helpful; generalities not followed up in the weeks to come, are worse than useless. Methods to be used in different lessons can be outlined, and the material required may be enthusiastically described. The first instruction can be presented to the apprentices as a group. Individual tendencies need not be considered except insofar as they are expressed through questions asked by the apprentice.

The Test of Instruction. An excellent test of related instruction for apprentices is whether or not it will make the work easier, cheaper, or more interesting. Instruction which does not meet this test is futile and may as well be left out of the program. The requirements of making work easier includes both the standpoint of the apprentice and the standpoint of production as far as equipment in the shop is concerned. Cheaper work refers to the economical use of material and equipment, the saving of time and the development of different methods of doing work.

The most important of these three requirements is, of course, that of making the work more interesting. Young men will not do work very long which does not attract their interest, and this appeal must be maintained not only during the first month or year but continuously throughout the course.

Technical Foundry Subjects in the School. The course in related subjects should include a good foundation in elementary physics, chemistry and related subjects which apply to foundry work. Applications must be carefully pointed out; the apprentice must not be left to infer them.

The formal education of the apprentices will vary from eighth grade to high school graduates. The instructors teaching the related subjects will have to gear their instructions to the level that will prove satisfactory to the majority of the apprentices.

In this class the instructor should explain, so far as possible, all common phenomena of the foundry and should answer the many questions which will be asked regarding foundry matters.

Many apparently simple questions regarding foundry sciences are still subjects of dispute or research. The instructor can hold the interest and respect of the apprentices when such questions are brought up only if he is frank in his statement of the lack of knowledge on the subject.

Fundamental School Subjects. Mathematics, drawing, blueprint reading and industrial economics are essential in the schooling course. Mathematical proficiency is needed to calculate charges, contraction of metal, amounts of material and other factors; drawing and blueprint reading are both obviously needed and the economics of modern industry enter into the human and material problem in every part of production.

Cooperating with Foremen and Executives in the Matter of School Attendence. In the administration of school work as well as of plant training, it is important to adjust the work to the needs and requirements of shop officials. School attendence should be arranged so that it will interfere as little as possible with the regular routine of the shop.

The apprentice instructor will gain nothing by insisting that a certain apprentice attend school at the scheduled time if he is working on a rush job, when his school attendance may just as well be postponed to another day. The appreciation of a fair-minded shop official for this adjustment will strengthen the program. Shop officials frequently notice that certain apprentices are deficient in decimals or blueprint reading, or some other branch of instruction. When reports of this nature are made, the supervisor should make arrangements for special coaching in those subjects in which the apprentice is deficient.

Maintaining Interest by Means of School Instruction. The first glamor of the apprentice's work soon wears off and must be replaced by more fundamental interest based upon understanding of what the job really is. Related instruction is a most important factor in bringing these essentials before the young man.

The making of molds and cores, and the melting and pouring of metal, assume a new significance when the apprentice begins to understand some of the scientific facts which underlie these operations and learns of the countless years of experience upon which the art of founding has been built.

The interest of the apprentices in their trade can be deepened by graphic descriptions and illustrations in the course of school instruction and the part played by the foundry industry in everyday commercial life. More important still, the school instructor should encourage in the foundry apprentices an appreciation of the romance of modern industry, of the place of the foundry in industry and of their own opportunities as trained workers and citizens.

Social Activities of Apprentices. The apprentices should be the most promising and progressive group of young men in manufacturing organization. It is important that they become acquainted with each other and with the shop management, as far as possible, as the time will come when such acquaintance will be necessary for them to cooperate properly with the various officials and departments in the shop. They should develop a group consciousness.

Graduation. Graduation is the most important event in the career of the apprentice, both from the standpoint of the young man and the employer. The day of graduation is the day to which the young man has been looking forward for many years. It is necessary for the employer to attach to the event the importance which it deserves in the eyes of the apprentice. In many plants the graduation of apprentices is observed in as a happy spirit as any high school commencement.

Whatever the custom regarding graduation may be, it is important that the apprentice should be officially informed and congradulated as soon as the time is completed. If the contract includes a bonus, it is well to give the boy the check on the day of graduation. Unnecessary delay in this matter, resulting from lack of attention in clerical departments is inexcusable. The graduation should be announced publicly and a new rate of pay, appropriate to the new mechanic should be made effective immediately.

It is also important that the completion of an individual apprenticeship should be fully recognized in shop treatment of the young man whose status has changed. There is always a temptation to continue to treat the graduate as an apprentice for some time after his course is completed. It must be impressed upon the entire personnel by shop officials that the status of the young man has changed and that he should be shown in every way the respect due a mechanic.

The apprenticeship training programs now functioning are preparing a comparative small number of trained men compared with the number of trained men the foundry industry needs. The large foundries are accepting veterans of World War II for apprenticeship training. The veteran as an apprentice is considered a sound investment by the industry. The technical institutions of the United States are assisting in the educating of men for employment in the foundry industry. Technical positions of the foundry industry and the education required of these positions will be discussed in the following chapter.

CHAPTER VI

TECHNICAL EDUCATION FOR THE FOUNDRY INDUSTRY

The technical positions of the foundry industry are held by individuals who were either educated in technical schools or by one of the various programs that the foundry industry has devised. Technicians are trained to perform a specific task or a group of tasks such as; sand testing, casting inspecting, heat treating, sand preparation and special machine operations. The production foundries and the automotive industry employs over eighty-five per-cent of the foundry technicians educated by technical institutions, jobbing foundries employ the remaining fifteen per-cent. The technical education required by some of the technical positions is equivalent to that education required of a mechanical engineer, still other technical positions require some specialized training beyond a high school education.

The Purpose of this Chapter. The purpose of this chapter is to acquaint the reader with some of the various types of technical education that technicians employed in the foundry industry are required to have. The technical instructions offered at some of the technical schools will be discussed, also the technical instructions that the foundry industry deems necessary in this era of mass production. The discussions will only concern those technical positions that are most common in the foundry industry. The fact is acknowledged that there are technical positions in speciality and jobbing foundries that are important to those types of foundries. These positions are few in number and to discuss them to any length whatsoever would require extensive research. Part B of this chapter will aid veterans of World War II in selecting a technical position that the service training they had recieved would be of some advantage in the modern foundry. These positions will concern both Army and Navy Technicians.

Need for Technicians in the Foundry Industry. The American foundry industry needs thousands of men to bring its technical force up to peacetime standards. Foundries met wartime demands for castings with small, inexperienced crews by working long hours. Now openings exist for technicians, in all types of foundry jobs, in most of America's foundries. Troubled with a shortage of technicians, foundries find it impossible to meet reconversion and reconstruction demands for castings. Great tonnages of castings needed by other industries are being supplied slowly because foundries lack sufficient technicians and workers with adequate training and experience.

Vocational and technical schools are graduating some foundry students, foundry apprentice training programs are starting again, and veterans are entering the foundry industry. But this does not fill industry's requirements. The need still exists for more technicians and skilled workers.

PART A

COMMON TECHNICAL POSITIONS OF THE FOUNDRY INDUSTRY

The technical positions in the foundry industry vary due to the numerous types of castings foundries produce. The positions that will be discussed are those most common in the foundry industry. The education and special training required for each position will be discussed. The following departments of foundries are usually supervised by foremen or technicians. The departments are; molding, coremaking, melting, finishing, and control. The position of foreman or technician of the departments mentioned will be discussed in the sequence mentioned.

Foreman of Molding Department. The supervisor of the molding department is generally classified as a foreman. The position of foreman in the molding department requires a high school education, eight to ten years experience in foundries, leader among the workers, familiar with local unions, working knowledge of time study methods, and experience in handling workmen. The American Foundryman Association and the National Founders Association have devised correspondence courses concerning labor relations, production control, solving foundry problems, and metallurgy for foremen and individuals seeking advancement.

The duties of the molding department foreman are numerous, those to follow are but a few of the important duties performed every day. The duties are; assigning work to bench, floor and machine molders: determining the cores, flasks, chills, and boards the molders will need for the day: assigning labors to supply the molders with necessary equipment: direct crane operations: determine amount of metal needed for the molds to be made during the day: and direct pouring and shaking out of molds.

Foreman of Coremaking Department. The supervision of the coremaking department is directed by the foreman of the department. The requirements for the foreman in the coremaking department are similiar to those requirements for foreman of the molding department. The foreman's position requires special training in; chemistry of core sands, binders, coremaking machines, types and control of ovens, core supports and core pastes and finishes. Correspondence courses are offered by the organizations mentioned previously for the coremaking department foreman and for those individuals desiring advancement.

The duties of the foreman of the coremaking department are just as numerous as those of the molding foreman. The following duties are but a few that the foreman performs daily: estimating amount and quality of core sand needed for the days work; direct placement of cores in oven and removal; assigning work to coremakers; direct the distribution of cores to the molders; and check core boxes before they are returned to storage.

Melting Department Technician. The technician in charge of the melting department is required to have two years of college or technical school education, with a major in metallurgy, basic related subjects such as; mathematics, chemistry, physics and foundry fuels. The technicians are constantly informed of the methods that are being developed in melting processes, by technical journals published by the National Founders Association.

The duties performed by the technician in the melting department are as follows: determining size, composition, and number of charges for cupola or furnace; performing tests on metal samples; checking pouring temperature of metal; directing cupola tender while the heat is being taken off; supervising charging crew; assist molding foreman during the pouring off; and directing the repair and replacement of cupola and furnace linings.

Foreman of Finishing Department. The education that is required for foremanship of the finishing department involves welding, sand blasting, grinding materials, fundamental metallurgy, blueprint reading, and basic mathematics. Technical instructions for the operating of testing equipment, such as; magna-flux, gamma-ray, and x-ray machines, are given through correspondence courses offered by the National Founders Association. The N. F. A, has a Short Term Training Program For Metal Finishing which a number of firms require the foreman of the finishing department to take.

The duties of the foreman of the finishing department are as follows: inspect salvable castings to determine how the castings can be repaired; direct the repairing of castings; determine what method of finishing special castings should have; assigning work to helpers; and notifing shipping clerk of finished castings.

Control Laboratory Technicians. Small foundries have one or two technicians in the control laboratory. The large foundries have a staff of technicians to handle the testing of incoming materials and the finished castings. The technicians are required to have a college education, majoring in the specific type of work they are doing, for example the foundry chemist is required to have a major in chemistry, the N. F. A. publish technical journals through which the technicians are informed of the new materials, methods, and processes that are being developed.

The duties of the technicians in the control laboratory are those of checking and testing materials used in the foundry and making analyses of finished castings. The foundry sands are checked for grain size, clay content, and silt. The prepared sands are tested for permeability, green strength, dry strength and moisture content. Finished castings are checked by the use of, gamma-ray, x-ray, and magna-flux machines before the castings are sent to customers. Chemical analyses are made of the metal and materials used in the cupola or furnace. The modern foundries have positions for more technicians than technical schools and colleges can supply.

PART B

MILITARY ASSIGNMENTS RELATED TO THE FOUNDRY INDUSTRY

Many veterans have acquired skills in the service that enable them to assume foundry positions with the minimum of additional training. In addition, veterans often recieve credit toward completion of foundry training courses for skills learned in service. Many of the workers needed to meet present and future requirements for castings are being selected from the ranks of veterans. Some foundries are pledged to make up twenty-five per cent of their employees from ex-service men and women.

There are many types of foundry work, but the list which follows shows only some of the more common and broader classifications of foundry workers. Likewise, for the sake of simplicity, all military occupations are not shown. However, servicemen can gain some idea of the foundry work for which they are best fitted by comparing their military ratings with the foundry occupations shown.

To use the list, select the military assignments held during the term of service, or the ones most closely related to those held. Opposite each military assignment are one or more numbers which indicate the type of foundry work related to the military assignment selected. On the list of foundry occupations opposite a key number find the name and description of a foundry job for which the applicant has been fitted by the military training recieved.

ARMY ASSIGNMENTS

Military Assignment	Key Number
Aerial Photographer	2, 6, 31, 46
Aerial Gunner	6, 14, 25, 31, 35
Airplane and Engine Mechanic	6, 14, 23, 30, 32, 36, 39
Airplane Armorer	6, 14, 23, 30, 32, 35, 36
Airplane Maintenance Chief	6, 14, 23, 25, 30, 32, 35, 36
Airplane Woodworker	3, 4, 38, 40
Armorer	6, 14, 23, 24, 30, 31, 35, 36
Artillery Mechanic	6, 14, 23, 24, 25, 30, 31, 32, 35, 36
Blacksmith	1, 5, 8, 16, 17, 19, 23, 24, 42
Bombardier	6, 14, 25, 31, 35
Bricklayer	5, 8, 22, 41, 42
Calker	1, 5, 8, 22, 41
Carpenter	3, 4, 38, 40
Chemical Engineer	7, 21, 27, 28, 31, 46
Chemical Laboratory Assistant	7, 27, 28, 46
Chief Storekeeper	11, 12, 13
Classification Specialist	9, 11, 12, 13
Crane Operator	5, 8, 15, 24
Dental Laboratory Technician	26, 34, 37
Draftsman	2, 18, 29, 44
Electrician	19, 20, 21
Eletroplater	21, 27, 39
Financial Clerk	10, 11, 12, 13, 43
Heat Treater	1, 16, 17, 19, 24, 31

Military Assignment	Key Number
Locomotive Mechanic	23, 30, 32
Machinist	23, 25, 30, 31, 32, 36
Master Gunner	2, 18, 29, 44, 46
Mechanic	6, 25, 30, 32, 36
Medical Laboratory Technician	21, 27, 28, 46
Millwright	3, 4, 38, 40
Model Maker	29, 34, 37, 38, 40
Molder	1, 5, 6, 8, 14, 16, 17, 19, 22, 34, 35, 41
Patternmaker	3, 6, 29, 34, 36, 37, 38, 40
Photographic Laboratory Technician	2, 27, 28, 31, 46
Supply Clerk	10, 11, 12, 13, 43
Truck Driver	5, 8, 15, 33, 42, 45
Welder	5, 23, 31, 32
Winch Operator	15, 33, 42, 45
X-ray Technician	6, 27, 28, 31, 46

NAVY ASSIGNMENTS

Military Assignment	Key Number
Aerographer's Mate	18, 25, 44
Aviation Boatswain's Mate	5, 8, 15, 42, 45
Aviation Electrician's Mate	19, 20, 21, 25
Aviation Machinist's Mate	6, 23, 25, 30, 32, 36
Aviation Metalsmith	5, 6, 18, 21, 24, 39, 44
Aviation Ordnanceman	6, 23, 24, 29, 36
Boatswain's Mate	5, 8, 14, 15, 35, 41, 42, 45
Boilermaker	5, 8, 22, 42

Military Assignment	Key Number
Carpenter's Mate	3, 4, 38, 40
Carpenter's Mate (Draftsman)	2, 18, 44
Driver	5, 8, 22, 42
Electrician's Mate	19, 20, 21, 25
Fire Controlman	6, 23, 24, 29, 30, 32
Fireman	1, 16, 17, 19, 24
Gunner's Mate	6, 23, 25, 30, 32
Machinist's Mate	6, 23, 25, 30, 32, 36
Machinist's Mate (Shop Machinist)	6, 23, 25, 29, 30, 32, 36
Metalsmith	5, 6, 8, 24, 39
Mineman	6, 14, 15, 21, 35, 41
Molder	1, 5, 6, 8, 14, 16, 17, 19, 22, 34, 35, 41
Motor Machinist's Mate	23, 32, 36
Painter	2, 5, 8, 18, 44
Patternmaker	3, 6, 29, 34, 36, 37, 38, 40
Pharmacist's Mate	21, 27, 28, 46
Pharmacist's Mate (Dental)	26
Photographer's Mate	2, 6, 27, 28, 31, 46
Radio Technician	20, 21, 25
Shipfitter	5, 8, 18, 23, 32, 44
Special Artificer	25
Storekeeper	9, 10, 11, 12, 13, 33, 43
Yeoman	9, 10, 11, 12, 13, 33, 43

FOUNDRY OCCUPATIONS

Key Number	Position	Description of Work
1	Air Furnace Operator	Operates hearth type furnaces used chiefly for melting malleable iron. Controls powdered coal or oil and air for combustion. Adjusts slag and metal composition. Responible for repair and maintenance of furnace roof, sidewalls and bottom.
2	Blueprint Machine Operator	Operates machine which makes blueprints for foundry, engineering department, machine shop and assembly department.
3	Carpenter, Flask	Makes and repairs wooden flasks for special molds.
4	Carpenter, Shop	Does wood construction and repair work for foundry.
5	Casting Cleaner	Cleans casting using variety of mechanical equipment, including tumblers, tumblast, sandblast, hydroblast and several types of grinders.
6	Castings Inspector	Makes visual examination of castings, uses gages and miscellaneous testing equipment.
7	Chemist	Operates chemical laboratory for the analysis and testing of raw materials and finished products. Aids in control of foundry operations by checking casting production operations such as melting.
8	Chipper	Uses pneumatic chisel to

Key Number	Position	Description of Work
		clean castings. Removes rough spots, fins, surface protrusions from unfinished castings.
9	Clerk, Employment	Interviews job seekers. Keeps records in personnel office.
10	Clerk, Payroll	Maintains records of salaries paid, deductions, etc.
11	Clerk, Receiving	Handles incoming shipments. Receives, checks and makes records of materials and supplies received by foundry.
12	Clerk, Shipping	Maintains records of castings shipped to customers.
13	Clerk, Stockroom	Passes out tools and materials to workmen. Keeps records.
14	Coremaker	Makes cores for special casting surfaces by packing prepared sand into coreboxes. Turns out sand shapes on supports and bakes them in core ovens.
15	Crane Operator	Operates cranes handling ladles, flasks, etc., in foundry. Also handles coke, limestone, pig iron and scrap.
16	Crucible Furnace Operator	Operates fixed and removable crucible type furnaces and other pot type furnaces for melting nonferrous alloys. Controls gas or oil and air to produce proper combustion conditions and to achieve desired melting rate. Maintains furnaces and crucibles.

Key Number	Position	Description of Work
17	Cupola Operator	Operates cupola furnace for melting iron. Supervises repair of refractory lining, preparation of metal, coke and flux charges. Makes chill tests of metal melted. Adds alloys to molten metal to produce special types of iron.
18	Draftsman	Makes drawings of castings to be produced, of repairs and alterations to be made to equipment or plant. May aid in casting design.
19	Electric Furnace Operator	Operates arc furnace or induction furnace for melting many types of alloys. Supervises care of refractory lining and preparation of metal charges, handles electrical controls, adjusts furnace operation and metal temperature and composition, on basis of control tests.
20	Electrician	Responsible for installation, maintenance and repair of foundry electrical equipment and electrical circuits. Works with power lines, tranformers, electric furnaces, motors, magnetic cranes, etc.
21	Electroplater	Cleans castings to be plated by means of various solutions. Plates castings with copper, nickel, chromium, cadmium, etc. Prepares and tests cleaning solutions and plating baths.
22	Furnace and Ladle Liner	Lines heat treating furnaces and melting fur-

Key Number	Position	Description of Work
		naces; also ladles used for handling molten metal. Uses brick, stone and prepared refractory mixtures.
23	General Repairman	Makes miscellaneous repairs to foundry equipment and buildings. Works with maintenance man when necessary.
24	Heat Treater	Loads and operates furnaces for heat treating castings. Cools castings in oil or water or other media to produce certain mechanical properties. May heat treat chipping chisels and other shop tools and repair parts.
25	Instrument Repairman	Repairs, maintains and tests gages, laboratory apparatus and foundry control devices.
26	Investment Caster	Operates machinery for production of wax patterns and special molds, uses ovens, etc., to prepare molds. Melts and casts metal in these molds, using small centrifugal casting equipment. Cleans and finishes investment castings.
27	Laboratory Asst., Chemical	Makes routine chemical analysis of metals, fuels, slags, fluxes. Assists chemist and may work on research problems. May make sand tests, employing sand testing instruments. May help with metallurgical work.
28	Laboratory Asst., Metallurgical	Prepares and examines metal specimens using microscope. Makes mechanical

Key Number	Position	Description of Work
		tests of cast specimens. May make temperature measurements, sand tests and others. Sometimes assists in chemical laboratory. May work in metallurgical research problems.
29	Layout Man	Lays out repair parts to be made. Lays out machining to be done on castings. Follows blueprints and works to close dimensional tolerances.
30	Machinist	Rough and finish machining on castings, may assist maintenance mechanic.
31	Magnaflux Inspector	Examines castings with magnetic inspection equipment; also uses ultraviolet light.
32	Maintenance Mechanic	Repairs and maintains molding machines, conveyors, compressors, motors, cranes and other mechanical foundry equipment.
33	Materials Handler	Keeps molders, coremakers and other foundry workers supplied with sand, flasks and miscellaneous material. Handles patterns between pattern storage, molding floor and pattern shop.
34	Molder, Plaster	Makes molds of plaster for the production of certain types of castings.
35	Molder, Sand	Makes molds for castings production by packing specially prepared sand around patterns. Depending on type, size and number of castings needed,

Key Number	Position	Description of Work
		the molding operation may be done mechanically or by hand. Pours molds in some foundries.
36	Patternmaker, Metal	Uses standard metalworking tools to make metal patterns for use of sand molder or plaster molder.
37	Patternmaker, Plaster	Makes plaster patterns used by sand molders for production of molds. May also make plaster models, check core-boxes by making plaster cores, etc.
38	Patternmaker, Wood	Uses standard woodworking tools to make patterns for castings to be produced by sand molder. Also makes coreboxes for core production.
39	Polisher and Buffer	Puts special surface finish on castings by means of motor-driven brushes, cloth wheels and special polishing compounds.
40	Rigger	Rigs patterns for repetitive casting production. Makes and mounts gates, risers, etc., on patterns for mechanized production.
41	Sandmixer	Uses mechanical sand mixing equipment to prepare various sand mixtures for molds and cores. Measures sand, binders and water.
42	Shakeout Man	Removes castings from sand molds. May also assist in sand reconditioning, moving flasks to storage and in cleaning the castings.
43	Timekeeper	Responsible for records

Key Number	Position	Description of Work
		of hours worked, time lost, vacations, etc.
44	Tracer	Traces drawings made by draftsman on special cloth prior to blueprinting. May aid draftsman.
45	Truckdriver	Drives truck making pick-ups and deliveries outside of foundry. May operate materials handling trucks inside foundry.
46	X-ray Technician	Confirms internal soundness of castings by means of x-rays; develops films, mixes solutions.

This list should give the reader a reasonable cross section of the types of jobs and positions that are available to the service trained veterans of World War II. Part C of this chapter is a proposed course of study for those individuals interested in technical training for foundry positions. This course of study concerns the general education that the majority of foundry technical positions require.

PART C

PROPOSED COURSE OF STUDY FOR TECHNICAL FOUNDRY POSITIONS

The following course of study for technical foundry workers is proposed for use in two year technical programs. This course of study is also proposed for those individuals now employed and desiring to advance in position through correspondence courses.

PROPOSED COURSE OF STUDY

Blue Prints - Sketches - Models

Describe the use of these in the Foundry Industry along with the regular course.

History of the Foundry Industry

Where has and where does the Foundry Industry fit into the industrial scheme?

Mathematics

Attention should be paid to mathematics as it can be applied to simple chemistry and physics, accounting, shop overhead and in the algebraic equations necessary for compounding alloy charges.

Safety

The cost of shop safety and the offsetting rebates practiced by Industrial Insurance Corporations. Problems of enforcing and benefits in employee morale arising from safe practices and good housekeeping.

Elementary Costs

The simple factors influencing production methods.

Pattern, Molds and Dies

Special attention to moldability in relation to conditions within the shop. Practical limits in respect to draw, depth, core support, etc.

Core Making

Core composition and construction with some attention to the physics and chemistry of the process.

Molding

Same as for cores.

Metals, Melting and Pouring

Include factors affecting the efficiency of the melting medium and proper methods of handling metal from same to the mold.

Gating and Risering

Practical and theoretical design of gates for various alloys. Purpose and performance of each and attention to improving their efficiency.

Quality Control

Concentrated attention to the selection of materials and control through the plant and other factors in handling and processing which go to make for quality products.

Finishing

Finishing methods with attention to salability, accuracy and metallurgical considerations.

Maintenance Problems

Preventive maintenance and its effect upon scheduling of production.

Cost Control

Planning of production with cost factors in mind.

Job Estimating

Choices of method and materials as well as selection of proper alloy in relation to the design of the part.

Advance Foundry Problems

Computation of complex charges. Interpretation of specifications and procedures. Compilation of test results. Coordination of the various steps in the process, and balancing for best efficiency. This includes metal, cores, molding, cleaning, etc., all planned for the most perfect possible balance.

Labor, Industrial and Contract Law

The legal sources controlling the operation of a company and the conduct of the men managing and working in same.

The technical positions of the foundry industry that have been described in this chapter are but a few of the important technical positions now present in the industry. The described education required by these positions and the proposed course of study for technical foundry positions are considered basic to the modern foundries. The chapter to follow will discuss college level education for the foundry industry.

CHAPTER VII

ENGINEERING EDUCATION FOR THE FOUNDRY INDUSTRIES

There are over five thousand castings companies in the United States. Of these there are over twelve hundred employing more than one hundred men, and nine hundred and forty-four more employing more than fifty men. These foundries employ a minimum of four hundred seventy-five thousand men. If it is assumed empirically, that one member of management is required for every twenty-five employees, then there are nineteen thousand such positions at the present time. If only one-half of these are to be engineering and technical school graduates (approximately ten thousand) then the industry is confronted with the generation of a continuing effort to supply candidates for such education. The industry must also, by one means or another, support their education and then provide the requisite training for the induction of these graduates into the industry.

In 1824 the first English speaking collegiate school of engineering was established at Rensselaer Polytechnic Institute in Troy, New York. Prior to that time all engineering knowledge was transferred through the laborious apprentice, craftsman, master cycle. Many industries were quick to adopt engineering education. This was true of the construction and, later on, the electrical, mining, mechanical and chemical industries.

<u>Foundry Industry Last to Change to Engineering Education.</u>

The foundry industry retained the old methods for over a century before serious changes were contemplated. More recently, economic conditions plus regulating local, state and federal measures have served to break up the old cycle. Thus the industry is presently in need of engineering knowledge to bridge the gap in its existence and to keep it in step with the tempo of the industries it supplies with basic products. (38, page 59)

The Purpose of this Chapter. This chapter, therefore, has a threefold purpose: (1) to recrystallize the objectives of engineering education as applied to the foundry industry, (2) to discuss the needs of engineering education for the present executive, managerial and supervisory members of the industry and (3) to provide the potential engineer with opinions, suggestions and objectives of the present type of training they are receiving, which in turn will serve as a basis for a more thoroughly refined analysis of industry requirements blended with actual experience. (32, page 29)

PART A

THE FOUNDRY INDUSTRY

The foundry industry is an important basic industry doing an annual business volume of five billion dollars creating sixteen million tons of castings and employing by itself and in those industries which it supports over five hundred thousand persons. In doing so it manufactures castings of gray iron, steel, malleable iron, copper bearing non-ferrous metals, light non-ferrous metals, and variety of die casting alloys. Over five thousand plants varying from a few employees to over two thousand are divided among every industrial center of the nation.

The Growth of Engineering Professions Since 1910. The report recently issued by the Engineer's Joint Council gives further evidence to this fact of growth. Since 1910 the profession has grown from approximately eighty-five thousand to about three hundred twenty-five thousand members. The numerous industries that have availed themselves of graduates include the electrical, machinery, public works, and steel, as well as those generally looked upon as competing industries such as welding and plastics. (1, page 73)

Foundry Industry Developed by Engineering Methods. The foundry industry has made extensive use of engineering in the design and development of productive equipment. Only recently has this "engineering method" found application in the products of the foundry. The need for a scientific approach to foundry problems and methods has been a subject of considerable discussion and has been pointed out in various talks and articles. (1, page 72)

The Foundry Industry in Cooperation With Educational Institutions. The industry has worked closely with educational institutions through the American Foundrymen's Association and the various trade societies on many technical subjects. This is especially true of the Educational Division of the

American Foundrymen's Association under the direction of Fred G. Sefing as chairman, and H. F. Scobie. This latter work has resulted in a variety of magazine articles and papers which have become a background for many educational activities. These references include "College Foundry Courses", "A University Course in Foundry Control Methods", "Foundry Practice for Engineering Students", and "College Graduates in the Castings Industry".

Non-Scholastic Qualifications. Foundry management seeks certain qualifications in graduate engineers which are the result of prior experience of foundry management. In the past, graduates have been too unsettled in their jobs because of their desire to progress too fast without going through a program of sound development. This results in a type of engineer who eventually gets "promoted out" of the firm. The graduate must also possess the ability to impress favorably other staff members at the outset and to further this regard through desirable action as time passes. Tolerance, friendliness and sincere interest in the members of the worker group are essential, but the graduate must also appreciate that he and his crew or department must meet or exceed standards of quality and quantity in order for him, or his crew, to become an economic asset to the firm. Diplomatic honesty in reports and interdepartmental cooperation, acknowledgement of ideas, suggestions and good work, plus a willing attitude, are essential to the success of the individual as well as to the success of the company.

The Foundry Educational Foundation has been successfully concieved and implemented to bring about the desires of the industry in regard to the preparation and attraction of engineering graduates. The support of the founding members and the voluntary efforts of some of the leading foundry executives of these societies have provided the impetus and means of accomplishing the desires of the industry. No better proof can be found for the interest of foundry management than in their providing funds for the realization of these needs. Educated and trained men are actively being sought by the leading foundry firms of the nation. (4, page 58)

PART B

THE UNIVERSITIES

Engineering education in the United States is undergoing a major revision at present. As engineering education progressed through the nineteenth and presently through the twentieth century, new courses were constantly added. These, in turn, would displace humanistic, political, economic and business courses untill the pre-World War II era when engineers, educators and businessmen alike suddenly realized that the graduate engineer was lacking in some qualities. Various societies became interested in this problem. In time, this took the form of magazine articles, papers and propaganda. (42, page 77)

John S. Crout, in proposing a plan for post-graduate training of engineers, is quoted:

> His work has brought him out of his natural habitat of the laboratory, drafting room, foundry, mine and factory to a position of prestige in a world governed by social, economic and political forces not taught him in the usual engineering curriculum.

His plan is intended to show how these omissions can be eliminated by a post-graduate study and training plan.
(14, page 490)

James C. Zeder approaches the same problem by analyzing the common complaints of engineers in industry and recommending self-correcting procedures for the individual. Specific points of engineering success are identified as (a) ability to get along with people, (b) ability to look beyond his own department to see where he can be of help to the rest of the organization, and (c) ability to plan his own progress by eliminating shortcomings from his personal mechanism.
(45, page 17)

Prior to World War II such things as X-ray, spectrographs, spectrophotometers, magnaflux, supermicrometers and electron microscopes were more objects of curiosity than of widespread use. Now they are standard industrial tools of a fundamental nature.

Functions of the University. The university function is to educate rather than train student engineers. Again the educational world uniformly strives to become the means by which fundamentals are taught. These vary with industrial usage and technical development, but always are subjects which are applicable to a variety of industrial processes and not restricted to one narrow field. Dr. W. G. Van Note points out this trend in this quotation:

> --the philosophy underlying engineering education is today based more and more on a broading of the base of engineering education in which strong emphasis is placed on fundamentals, rigorous instruction in the use of English, and the inclusion of a well planned social humanistic stem. (42, page 73)

Industry Should Train Engineers. Virtually all bulletins issued by colleges of engineering delineate the same principles in their prefaces. Professional experience and training are left for industry and the engineering graduate to accomplish. (15, page 60)

Student Selection. The selection of students has become possible to an ever increasing degree of refinement through over flowing numbers of applications for entrance. This has enabled each engineering college to restrict entrants to those whose qualifications predict successful undergraduate work and professional life upon graduation. The type of student formly entering college with no observable ability to meet the ultimate requirements of the university is becoming a rarity. At some engineering colleges, the post-secondary technical school is being developed for those students unable to meet the requirements.

Student Options. Fundamental studies during the first year of the engineering college curriculum are arranged to permit a student the option of electing or changing his major course after the first year. Some university officials actively recommend the idea of preliminary groundwork, at a liberal arts college followed by two or three years of study at the engineering college. (42, page 77)

Elective courses tend to be controlled through the establishing of sequences or stems. This is contrary to the freedom of choice which has characterized elective subjects for several decades. The sequence may be only a few or consist of many courses in such fields as the social studies, business administration or in the purely cultural field. (42, page 77)

PART C

CONCLUSIONS

Industry generally divides its employees into classifications along the following lines: (a) executive, management, (b) staff, technical, sales, (c) supervision, (d) skilled mechanics, (e) operators and semi-skilled, and (f) laborers and helpers. Preparation for the last three brackets does not require college level education. For the first three, a college education is a desirable shortcut to greater efficiency and broader knowledge of an industrial enterprise and is also a better preparation for managerial duties.

Regular university level education does not fully prepare a graduate for industrial or business management or even for technical proficiency. The graduate is grounded in fundamentals and an understanding of science, which is a pathway to greater knowledge. The top achievement of this graduate is to have thoroughly developed his powers of ingenuity, backed by basic knowledge, to the end that his intelligence can be efficiently put to constructive use.

Preparation for managerial and staff responsibilities must necessarily go beyond education. A student has, at graduation, invested heavily in the technical phases of his preparation. The training in basic techniques and procedures is by precedent the responsibility of industry. Customarily, a scheduled training program is the implement by which this is achieved. The student bears a secondary responsibility in that he continues to study those subjects which his formal training did not provide and he accepts, during his training, a salary usually not more than that paid an operator or semi-skilled workman.

University officials have evidenced both interest and cooperation in regard to the formulation of a foundry educational program. The prior activities of the various societies in the industry and the implementing of their wishes through the Foundry Educational Foundation have served to implant the aura of a well organized business among students and faculty alike in regard to the foundry companies. It is this unified approach which the universities recognize in contrast to individual wishes of seperate companies.

Education for the Foundry Industry. The varied operations which characterize the foundry industry involve several different kinds of engineering. No four or five-year collegate curriculum can accomplish the necessary education which a so-called "foundry engineer" would require. There is a field of "foundry engineering" but it will be served by all kinds of engineers. More common among them will be metallurgical, chemical, mechanical and industrial engineering plus considerable opportunity for engineering administration graduates, as well as need for some electrical engineers.

The desires of the foundry industry as expressed through the concept of the Foundry Educational Foundation, the personal views of individual members and expressions in the literature which reflect the experience of the leadership up to this time, can be satisfied with very little in the way of supplementary courses. This is largely due to the development of desirable curriculums which have been installed in some universities by alert educators profiting through the successes and failures of the past. The following universities have developed curriculums to meet the needs of and the demands of the foundry industry. They are; Cornell University, University of Alabama, University of Cincinnati, and the University of Wisconsin.

The result is a desirable alteration of engineering curriculums to provide fundamental studies in other fields to create a more adequately balanced personality in graduate engineers. In turn, their chances for business and managerial success are thereby enhanced.

<u>Curriculum Changes Needed</u>. The university level of engineering education has been characterized by a persistence of efforts to restrict the major portion of the curriculums to studies of fundamental science. Subjects which have a

narrow field of application are deleted and, conversely, those which have wide uses are considered and developed. The present tendency is to expand the humanistic studies at the expense of specialized engineering courses in the expectation of a more desirable personality among engineering graduates.

University officials and staffs are emphatic in their efforts to provide education which will offer the broadest opportunities to their graduates by not restricting the employment potential to a narrow field. They repeat that training for a specific industry or company is the task of that industry or company. Education is a part of the preparation needed to qualify a graduate for the responsibilities of management.

Universities offering a full program of engineering education, including metallurgical engineering, can meet the needs of the foundry industry with very little modification of present curriculums. Where sufficient elective hours are available, any engineering program can be adapted through the guided selection of proper subjects. Usually, the refinement and extension of the general foundry courses for all engineers is desirable. The addition of a few technical courses bearing on the foundry processes to bring about a focus of the student's fundamental knowledge towards foundry technology will complete the picture. The presence in the area of an active progressive foundry industry will supplement this education through direct observation by students during inspection trips.

PROGRAM SUGGESTED BY THE FOUNDRY EDUCATIONAL FOUNDATION

The following program has been recommended by the Foundry Educational Foundation, to be used in the institutions that have recieved grants from the Foundation. The program varies slightly in some minor instances, but the basic subject requirements are adhered to by the seven institutions recieving grants from the Foundation. The institutions recieving grants from the Foundry Educational Foundation are: Case Institute of Technology, Cornell University, Massachusetts Institute of Technology, Northwestern Technological Institute, University of Alabama, University of Cincinnati, and the University of Wisconsin.

SUGGESTED PROGRAM

Freshman Year First Term

Subject	Hours per week Rec.	Lab.	Sem. Hr. Cr.
Anal. Geom.	5	0	5
Physics I	3	0	3
Chemistry I	4	3	5
Composition I	3	0	3
Eng. Drawing I	0	4	2
Desc. Geom. I	1	1	1
Phys. Education	0	3	0
	16	11	19

Freshman Year Second Term

Subject	Rec.	Lab.	Sem. Hr. Cr.
Calculus I	5	0	5
Physics II	3	0	3
Chemistry II	4	3	5
Composition II	3	0	3
Eng. Drawing II	0	4	2
Desc. Geom. II	1	1	1
Physical Ed.	0	3	0
	16	11	19

Sophomore Year First Term

Subject	Rec.	Lab.	Sem. Hr. Cr.
Calculus II	3	0	3
Physics III	3	0	3
Phys. Lab. I	0	2	1
Literature I	3	0	3
History I	3	0	3
Statics	3	0	3
Intro. Met.	2	5	4
Phys. Education	0	3	0
	17	10	20

Sophomore Year Second Term

Calculus III	3	0	3
Physics IV	3	0	3
Phys. Lab. II	0	2	1
Literature II	3	0	3
History II	3	0	3
Dynamics	3	0	3
Met. Calc.	0	3	1
Mineralogy	2	2	3
Phys. Education	0	3	0
	17	10	20

Summer--Foundry and Machine Shop, 2 weeks, 40 hours a week, 2 sem. hrs. cr.

Junior Year First Term

Economics	3	0	3
Mech. of Mat.	3	0	3
Phys. Test Lab.	0	2	1
Ore Dr. & Mat. Prep.	3	2	4
Physical Chem. I	3	0	3
Met. Processes	3	5	5
Phys. Education	0	3	0
	15	12	19

Junior Year Second Term

Non-Tech. Ele.	3	0	3
Mach. Design.	3	2	4
DC, AC Circ. & Mach.	3	2	4
Met. of Iron & Steel	3	2	4
Phys. Chem. II	3	0	3
Met. Lab.	0	3	1
Phys. Education	0	3	0
	15	12	19

Summer--Inspection trip, 2 weeks, 2 sem. hrs. cr.

Senior Year First Term

Subject	Hours per week Rec.	Lab.	Sem. Hr. Cr.
Non-Tech. Ele.	3	0	3
Phys. Met.	4	3	5
Ferrous Alloys	3	3	4
Non-Ferrous Prod. Met.	3	0	3
Metal Finishes *	2	1½	3
Thesis *		1½	1
	15	9	19

Senior Year Second Term

Subject	Rec.	Lab.	Sem. Hr. Cr.
Non-Tech. Ele.	3	0	3
Eng. Economy	3	0	3
Tech. Elect. *	3	0	3
Non-Ferrous Alloys	3	3	4
Electro-Met. *	2	0	2
Thesis *	1	6	4
	15	9	19

* In place of these five starred courses, a student may elect: THE FOUNDRY OPTION, consisting of Foundry Metallurgy I and II, Foundry Technology, and Personnel Management or a group of business courses of equivalent credit.

EDUCATIONAL STEMS OF INTEREST TO FOUNDRY MANAGEMENT

The following list of educational stems are of interest to foundry management. College students interested in employment in the foundry industry will find this suggested list of educational stems to be of great advantage when selecting courses in an institution that do not recieve grants from the Foundry Educational Foundation.

Social Humanics Stem

Composition and Literature

Fundamentals of grammar, expository writing, reading, value and appreciation of verse and prose. Expression through proper choice of words and construction.

General Psychology

Individual differences, intelligence, and emotions. Study of personality. Memory and learning. Motivating media. Application to industrial management.

History

World history of the twentieth century and up to present time. Background for economic, political and social structure of the modern world.

History of Science

Development of present day scientific knowledge from early history to current achievements. Includes all phases of science.

U. S. Government

A study of the political background and legislative methods of present day governments. Includes local, state and federal administrations.

Public Speaking

Presentation for committees and management groups. Technical and educational lecturing. Platform presence, audience interest and acceptance.

Engineering Stem

Fundamentals of the Casting Process

A course designed for study by all engineering students giving fundamental operations and striving for appreciation of the foundry as a metal forming process.

Foundry Technology I-II

A study of the application of science to foundry operations. The prior engineering fundamentals are focused upon the problems and operations of the foundry. Includes control of materials and process, maintenance of tolerances, metallurgical inspection and repair.

Casting Design

A study of patterns, molds, dies and casting design in their relationship to each other in the engineering of a foundry product. Emphasis on design of casting for metallurgical perfection.

Metallurgical Calculation

Calculations to determine requirements for metallurgical reactions in manufacturing operations.

Survey of Process Metallurgy

Appreciation course. Raw material production from mine to plant. Stresses condition and relative purity as same affect subsequent use.

Ferrous Alloys

Advanced study of alloy steels and cast iron (metallurgy, metalography, heat treatment, testing).

Non-Ferrous Alloys

Advanced study of non-ferrous alloys.

Engineering Economy

Selection of process or production design for greatest economy, quality, or both, as applied to a given product.

Industrial Administration Stem

Fundamentals of Economics

Theory of trade, credit, business cycles and motivating influences. Present world economics.

Fundamentals of Accounting I-II

Use of journals, ledgers, simple financial statements. Elements of cost and cost control. Use and need for various company records. Advanced courses cover overhead administration, corporate financial structure and dynamic use of cost data.

Business Law. Survey

Legal responsibilities and authority of management. Rights of ownership. Elements of contracts and kinds. Relationship to agencies and carriers. Effect of local, state and federal regulations.

Fundamentals of Industrial Organization

Organization of present day corporate and business management. Industrial trends. Required controls, problems of selling and marketing, purchasing and stores, manufacturing and research, distribution and costs, financing.

Corporation Finance

Financing of corporate or partnership enterprise. Regulations due to local, state and federal laws. Administration of income, financing of going business.

Marketing

Market product research, distribution channels, pricing and branding. The market structure and regulations affecting sales and distribution. Relation of sales to other departments.

Human Engineering Stem

<u>General Biology</u>

Fundamentals of plant and animal life, emphasizing man's place in this world.

<u>Advanced Psychology</u>

Human reaction to favorable and adverse stimuli. Study of resulting physiological and mental effects. Group psychology.

<u>Industrial Relations</u>

Theory of employee relations and policies. Selection, training, promotion, health and discharge technique. Collective bargaining, labor laws, safety codes, morale factors, job evaluation and wage systems are studied in relation to each other.

<u>Technobiology</u>

Principles of anatomy, physiology, psychology and health applied to job specification, machine design and facilities of the plant.

<u>Motion and Time Study</u>

Fundamentals of motion economy and time factors for human and mechanical motion. Technique of observation, charts, graphs and formulas are practiced. Relationships to other factors of industrial management is stressed.

Safety Engineering

Industrial safe practices. Engineering for prevention. Psychological factors of acceptance and maintenance of a safety conscious work force. Human and economic factors of safe management.

Techniques of Executive Control

Nature of supervision. Responsibilities of the line of authority. Stimulation of subordinates, contact with superiors and maintenance of support by associates.

Most of the courses shown are available in engineering colleges or in other schools of the same university. Some of the subject material may be included in other courses or regrouped under a different title. Choice of these subjects as electives, if they are not part of the regular course, will tend to satisfy the needs of the industry as previously expressed.

CHAPTER VIII

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The findings of this study will be presented in this chapter in two divisions; (1) summary of the discussion and (2) a statement of definate conclusions made on the basis of information presented. In addition to the brief summarization of the material and the statement of conclusions, a few recommendations are given in this final chapter.

PART A

SUMMARY

In the summary of this chapter an attempt will be made to present those significant data and other informational background, in a manner that will insure a comprehensive perspective of the problem as a whole.

Foundry work, and particularly production foundry work, is today one of the most gigantic industries of all times. The materials used in the industry are the best that modern science can produce, but in spite of the fact of these superior materials in use today, the industry is limited in its production due to the lack of sufficiently trained workers and technicians.

The recent establishment of the Foundry Educational Foundation and the reorganization of apprenticeship and technical training programs has relieved the limitations of the foundry industry to a slight degree. Veterans of World War II are being employed in foundry positions that the technical training they recieved in the service will be a great help to them.

This study is devoted to the levels of education that will be beneficial to those considering employment in foundries. The need for educated and trained personnel in the modern foundry has been considered in previous chapters.

As a further step in the development of this problem, a course of study has been suggested for each phase of education presented in this thesis, to aid in the organization and teaching of a course in foundry practice on the industrial arts, vocational, apprenticeship, technical and college levels of education. The units and instructional information presented, are not complete but should be helpful in understanding the procedure involved, and the necessary related information for the training of efficient personnel for the foundry industry.

PART B

CONCLUSIONS

Industrial Arts Courses. The junior and senior high schools that have an industrial arts program can add foundry practice to the program without a great additional expense. A course in foundry practice could involve other industrial arts subjects such as; drawing, patternmaking, machine shop and metal finishing. The industrial objectives can be attained through foundry parctice.

Vocational Education. The vocational high schools, in areas where the foundry industry is predominant, are training students for entry into the industry as either semi-skilled workers or as apprentices. Industry accepts the vocational training as part of the apprenticeship training required in the apprenticeship program. The vocational schools are meeting some of the demands of the industry and are training a small number of potential workers for the foundry industry.

Apprenticeship Education. The reorganization of the apprenticeship programs since the close of World War II has improved the technique of training apprentices for foundry work with the addition of a more elaborate program of related information. The apprenticeship programs are helping to supply trained workers for the foundry industry.

Technical Education. The technical education required of supervisers and inspectors employed in the industry ranges from a high school education to that type of education required for a mechanical engineer. The industry is in need of technicians to fill the positions left by retiring foundrymen. The veterans of World War II who recieved technical training for a specific job while in the service, with the aid of the tables on pages 63 to 72, will aid the veteran in gaining employment in the foundry industry.

Engineering Education. Engineering colleges, with slight revisions of present curriculums, could provide an ample supply of engineers with sufficient training to fill the vacancies present in the managerial, and engineering departments in the foundries. The institutions recieving grants from the Foundry Educational Foundation are training students to enter the industry as foundry engineers.

PART C

RECOMMENDATIONS

The recommendations made here are based upon the experiences of the writer as an employee of the foundry industry, as an instructor of foundry practice on the college level and as conclusions reached during the progress of this study. It is the belief of the writer that the following suggestions are worthy of consideration.

(1) The industrial arts programs of the junior and senior high schools should add a course in foundry practice to their present program. Such a course will acquaint the students with one of the five largest industries of the United States.

(2) The foundry industry should be consulted more frequently as to the types of trained employees they need, and the specific types of training they deem necessary for those employed in the industry.

(3) Colleges and universities offering courses in mechanical, electrical, and metallurgical engineering should have a course concerning foundry practice in the curriculum.

Problems for Further Study. Several problems that should have further study in regard to educational programs for the foundry indusrty have presented themselves during the course of this investigation. The following are listed as suggested items for further study.

(1) Additional study on the problem of this thesis, which might be the organization of a course of study for each of the courses outlined, and complete schedules for offering the courses.

(2) A design and floor plans of foundries, for students of the educational levels mentioned, with extensive study made in regard to heating, wiring, ventilation and painting.

(3) A survey of public schools having foundry practice included in the industrial arts curriculum. The questionnaire technique should be used to gather sufficient information to solve this problem.

(4) A survey of technical institutions offering courses in foundry practice and related subjects. The questionnaire technique can also be used for gathering information to be used in this study.

(5) Plan a program for the training of technicians that are now in demand by the foundry industry.

This study cannot be considered as complete and final since the foundry industry is making continuous changes in its methods of production and organization. It has been shown in this study that the present types of education are partially fulfilling the demands of the foundry industry.

It is with faith and hope that school men will see the need for the educating of personnel for employment in the foundries of America that this subject was chosen as a problem for development.

BIBOLOGRAPHY

1. American Foundryman, "College Graduates in the Castings Industry", American Foundryman, 10:72, November 1946.

2. American Foundrymen's Association, Alloy Cast Iron, A.F.A. Chicago, 1939, 257 pages.

3. Aston, James and Story, Edward B., Wrought Iron, A.M. Byers Company, Pittsburgh, Pennsylvania, 1939 97 pages.

4. Bankard, E. H., "Cooperative Education from the Industrial Side", American Foundryman, 12:58, August 1947.

5. Barnwell, George W., New Encyclopedia of Machine Shop Practice, William H. Wise and Company, Inc., 1941, 568 pages.

6. Bergevin, Paul S., Industrial Apprenticeship, McGraw-Hill Book Company, Inc., New York, 1947, 280 pages.

7. Bolland, Simpson, The Iron Founder, John Wiley and Sons, New York, 1892, 400 pages.

8. Bolland, Simpson, The Iron Founder - Supplement, John Wiley and Sons, New Tork, 1893, 400 pages.

9. Bollinger, J. W., Elementary Foundry Work, Thesis, Colorado Agriculture and Mechanical College, 1933, 132 pages.

10. Bonser, Frederick G., and Mossman, L. C., Industrial Arts for Elementary Schools, MacMillian Company, New York, 1927, 165 pages.

11. Boothe, Leslie, Foundry Calculations and Drawing, J. B. Lippincott Company, Philadelphia, 1936, 133 pages.

12. Bowman, Ernest L., Jobs in the Foundry, Science Research Associates, Chicago, 1940, 48 pages.

13. Campbell, Harry L., Metal Castings, John Wiley and Sons, New York, 1936, 318 pages.

14. Crout, J. S., "Engineering Training for Professional and Civil Life", Mining and Metallurgy, 18:490, October 1947.

15. Davis, George, "Industrial Foundry Program", American Foundryman, 11:60, February 1947.

16. Goodale, Stephen L., Chronology of Iron and Steel, The Penton Publishing Company, Cleveland, Ohio, 1931, 332 pages.

17. Hartley, Lawrence A., Elementary Foundry Technology, McGraw-Hill Book Company, New York, 1928, 423 pages.

18. Hartley, Lawrence A., The Fundamentals of Industrial Relations, National Founders Association, Chicago, 1935, 23 pages.

19. Hartley, Lawrence A., The Superpower of Friendship, National Founders Association, Chicago, 1935, 12 pages.

20. Hartley, Lawrence A., The Foundry Industry and the Boy, National Founders Association, Chicago, 1935, 23 pages.

21. Helm, Buell, A Course of Study for One Semester of Foundry Work in a High School, Typed Report, Oklahoma A. & M. College, 1946, 15 pages.

22. Joseph, T. L., "A Five-Year Plan for Engineering Education", Mining and Metallurgy, 12:602, December 1947.

23. Lewis, Melvin S., and Dillon, John H., Foundry, McGraw-Hill Book Company, New York, 1932, 77 pages.

24. MacNeil, W. J., "The Engineering Graduate and the Foundry Industry", American Foundryman, 4:21, October 1946.

25. McMillan, N. A., Casting in the School Shop, N. A. McMillan, Mimeograph, 1933, 53 pages.

26. Mead, L. C., "Machines--Tailored to Man Kindle New Engineering Design Concepts", S.A.E. Journal, page 41, December 1947.

27. Moldenke, Richard, The Principles of Iron Founding, McGraw-Hill Book Company, New York, 1930, 654 pages.

28. Newkirk, Louis V., The Industrial Arts Program, MacMillian Company, New York, 1948, 357 pages.

29. Palmer, R. H., Foundry Practice, John Wiley and Sons, New York, 1929, 450 pages.

30. Price, E. T., "What a Young Engineer Should Know", S.A.E. Journal, pages 28 - 29, October 1947.

31. Richards, William Allyn, Elementary Foundry Practice, MacMillan Company, New York, 1928, 121 pages.

32. Scobie, H. F., "Foundrymen and Vocational Schools", American Vocational Journal, 4:29, October 1946.

33. Scobie, H. F., "Foundry Practice for Engineering Students", Journal of Engineering Education, 37:9, May 1947.

34. Smith, Robert E., Units in Patternmaking and Founding, The McCormick-Mathers Publishing Company, Wichita, Kansas, 1939, 72 pages.

35. Stimpson, William C., and Gray, Burton L., Foundry Work, American Technical Society, Chicago, 1939, 216 pages.

36. Sturgis, Russell, A Dictionary of Architecture and Building, MacMillan Company, New York, 1901, 1060 pages.

37. Subcommittee on Training Graduate Engineers in Industry, Educational Division, A.F.A., "Foundry Training Course for College Graduates", Transactions, American Foundrymen's Association, 55:200, 1947.

38. Subcommittee on College Foundry Courses, Educational Division, A.F.A., "College Foundry Courses", American Foundryman, 1:59, July 1947.

39. Trade Industrial Education Department, Foundry Practice, University of Alabama Press, University of Alabama, 1946, 128 pages.

40. United States Department of Labor, Job Descriptions for Job Foundries, United States Government Printing Office, Washington, 1938, 128 pages.

41. United States Department of Labor, Dictionary of Occupational Titles, United States Government Printing Office, Washington, 1938, 1287 pages.

42. Van Note, W. G., "Modifications and Trends in Engineering Curricula", Journal of Engineering Education, 38:77, September 1947.

43. Wendt, R. E., Foundry Work, McGraw-Hill Book Company, New York, 1932, 128 pages.

44. Young, W. W., The Foundry, Stanford University Press, Palo Alp, California, 1941, 99 pages.

45. Zeder, J. C., "Making the Most of Engineering", S.A.E. Journal, page 17, September 1947.

TYPIST:

Alma H. Shepley

Stillwater, Oklahoma