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__Scope of Study__: In this report a review of the history and philosophy of industrial arts was made to establish a background for the selection and need of a foundry unit in a junior high school shop program. Included is a brief history of the development and growth of the foundry industry. Operation sheets for the manipulative processes in a foundry unit are also included.

__Findings and Conclusions__: The success of any industrial arts program is determined largely by how well the program is planned and administered. The purpose of this type of unit in shop is to give a student as many experiences as possible and to offer an outlet in his quest for exploration. The writer has attempted to include material in this report which will aid instructors in setting up a unit of this type.

ADVISOR'S APPROVAL John B. Tate

FOUNDRY FOR JUNIOR HIGH SCHOOL

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By

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Bachelor of Science
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CHAPTER I

INTRODUCTION

Much of the success of the industrial arts teacher depends upon his knowledge and interest in his field. To teach a successful unit in shop, the teacher must have a plan or course of study to go by. He must know what is to be done next and he must also be sure that he is leaving out nothing. It is hoped that this study will help the shop teacher to organize his foundry unit in such a manner that every student will receive the maximum from it.

Needs for the Study. The main purpose or need for this study is the desire of the writer to collect information in this area and to present it in such a way that it will be helpful to the present industrial arts teachers and, particularly, to those new teachers beginning their work in the field. The writer finds that very little research has been done in this field, so there is a felt need for this report.

Method of Research or Investigation. Only one method of research was employed in this report. The documentary method was used to study the material already written on the subject, to find information concerning the history and development of the foundry. The writer used his own shop as an example, and attempted to establish a course of study for this unit in foundry.

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 the field.

Anneal. To soften and toughen a metal by subjecting it to high heat and then cooling it. (7, page 110)

Binder. Material used to hold sand together. (7, page 51)

Blow Hole. Irregular cavity with smooth sides, caused by air or gas that is trapped in the metal during pouring. (12, page 16)

Bottom Board. A wood or metal plate placed on top of the drag before rolling it over, hence it becomes the bottom of the mold during the subsequent molding and pouring operations. (9, page 66)

Castings. Articles made by pouring molten metal into a mold and allowing it to solidify. (9, page 167)

Cast Iron. An iron containing so much carbon that it is not usually 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. (6, page 360)

Core. A body of sand used to form a cavity, and interior opening, or a hole through a casting. Cores may be made of green sand or dry sand. (6, page 139)

Core Plate. A metal plate on which cores are placed for baking in the oven. (6, page 140)

Facing. Any material placed on the face of the mold for the purpose of improving the surface of the casting. (13, page 19)

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. (10, page 51)

<u>Flask</u>. A frame or box of wood or metal that contains the sand mold. A flask may have two or more parts, the top being called the cope, the bottom the drag, and all intermediate parts the cheeks. (12, page 21)

<u>Founding</u>. 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. (6, page 1)

<u>Foundry</u>. An establishment in which molds are made and metal melted to pour them, for the production of marketable castings. (12, page 106)

<u>Green Sand</u>. A natural sand tempered with water and used to make a mold. (6, page 11)

<u>Green Sand Core</u>. A body of sand projecting into the mold cavity that is formed by the pattern during the molding process. (13, page 135)

<u>Green Sand Mold</u>. A mold composed of sand in its green or natural state. This type of mold can be poured with molten metal as soon as it is completed. (13, page 137)

<u>Non-ferrous Castings</u>. 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 materials for automobile and airplane parts. (8, page 28)

<u>Ornamental Foundry Work</u>. The art of preparing molds of a highly figured nature to be used for display, such as; statues, plaques, plates, panels, and jewelry. (6, page 29

<u>Parting Compound</u>. Any material used to prevent two surfaces of the mold from sticking together. (6, page 20)

<u>Pattern</u>. A form of wood, metal, or composition used to shape a cavity in a mold from which a casting is obtained. (6, page 10)

<u>Riser</u>. An opening through the cope into which the surplus metal rises above the top of the casting. It also feeds molten metal back into the casting as it shrinks during the change from a liquid to a solid state. (12, page 38)

<u>Sprue</u>. (1) An opening through the cope into which the molten metal is poured. It is connected to the mold cavity by a gate or series of gates: (2) The solidified metal that occupies the sprue passage after the mold has been poured. (13, page 42)

<u>Studies of Similar Nature</u>. In 1949 Mr. John H. Shepley wrote a similar report entitled: EDUCATION FOR THE FOUNDRY INDUSTRY. This report was sixty-eight pages including several diagrams and charts. Mr. Jarrell McCollum also wrote a similar report in 1952 entitled: THE FOUNDRY INDUSTRY IN OKLAHOMA. This writer had visited and studied fifty-one of the fifty-six foundrys in Oklahoma and interviewed officials of each foundry. In 1931 Mr. B. Helm wrote: A COURSE OF STUDY FOR ONE SEMESTER OF FOUNDRY WORK. This report was for the National Youth Administration Foundry School, and was of an advanced nature.

This chapter is used as an introduction in which is included the need for the study, method of research, and some selected definitions. Chapter two gives a brief history of foundry and the metal-casting industry. In chapter three the history and philosophy of Industrial Arts was presented to establish a background and need for this type of foundry unit in the shop. A basic course in foundry will be found in chapter four; a course which is to be offered in junior high school. Chapter four also includes operation sheets, which gives step by step procedures in foundry work. The conclusions and recommendations of this report are found in chapter five.

CHAPTER II

A BRIEF HISTORY OF THE CASTING PROCESS

Archeologists, geologists, and others have conclusive data to determine approximately the exact time that foundry work had its beginning. Explorers have found in the burial grounds and ruins, metal ornaments that were cast by the "Lost Wax Process." The year 4000 B. C. was estimated as the year the ornaments were cast.

Eurasiatic Steppe Belt. The earliest notice of metal occurred in the Eurasiatic Steppe Belt, now known as the Russian Black Sea area. The people of this area used forged copper articles. Gold was known to these people before copper, but copper, suited the purposes of this early work and was the material first cast by them. These people first used open molds made in sand and later in stone to produce cast shapes for both the tools of war and agriculture. Melting was first done in a clay-lined hole in the ground then later in a clay-lined hollow log; gradually more permanent melting furnaces were developed.

Orient 2000 B. C. As people migrated eastward, the foundry art was carried into the orient about 2000 B. C. Metal casting grew industrially, economically, and scientifically in the orient. Far eastern foundrymen achieved a mastery of bronze casting unknown in early times. They also developed an advanced knowledge of metallurgy. In China, for example, foundrymen began the casting of iron about 600 B. C. and in India, cast crucible steel was first produced about 500 A. D. The lost-wax techniques in which the Chinese used closed stone molds and sectional loam molds are found in some of their earliest work. With all their knowledge and "know how," foundry progress practically ceased about 1000 A. D. in the Orient.

Near East. The art of metal casting moved from the Orient into the Near East and the Mediterranean area. The Egyptians improved the well-developed casting techniques of the Orient and are credited with these two advancements: Refinements in the smelting and forging of iron and, the discovery of the lost-wax process of casting. The Egyptians also developed the use of the cope, drag, and core moldings. Although iron was known in this area as early as 2000 B. C., it was not generally cast until the fourteenth century A. D. Some important names and cast items connected with foundry development in ancient times are: Hiram of Type, a Phoenician foundryman, and his cast pillars for Solomon's temple. The famous Colossus of Rhodes, one of the seven wonders of the ancient world, was a huge statue made of castings and stood over 105 feet high. The Romans made use of many metals, but they added nothing to the progress of the art of founding metals.

Middle Ages. Progress on metal-casting was slow during the Middle Ages and the Renaissance, and the developments that did occur were shrouded in mystery. The Church and powerful feudal barons were the dominant forces and technical secrets they had were carefully guarded as their sole property. Three important advances came near the end of this period and they were; The development of blast furnaces for smelting iron, with the air supplied by manual and water-powered bellows. The development and use of the reverberatory furnaces, especially in non-ferrous melting, and the increased and improved use of loam molding. Leonardo da Vinci and Benvenuto Cellini relied on loam molding almost entirely to make their artistic articles. About this time the manufacture of bells and guns, both foundry products, had a great influence on the metal-casting industry. Vannoccio Biringuccio, the first true foundryman, was responsible for this influence and can be called the father of the foundry industry.

England 1730. Following the Renaissance, some important historical developments related to the metal-casting industry were; The craft guilds and their good and bad influences on the industry and, the development of coke as a fuel for the smelting furnaces by Abraham Darby of Coalbrookdale, England, in 1730. The invention of the cupola by John Wilkinson of England in 1794 and, the use of the Watt steam engine for better blast control on the first cupola.

Colonial America. Iron ore was first discovered in North America by an English expedition searching for gold, sent by Sir Walter Raleigh in 1585. The explorers found the ore on an island off the coast of North Carolina, but they were so eager to discover gold that they did not bother to take a sample back to England. It was iron ore sent to England from Jamestown, Virginia, that persuaded a group of Englishmen to build the first ironworks in America. About 1620 they selected a site on the banks of Falling Creek, Virginia. The Indian tribe that inhabited that region, looked with suspicion and fear upon the strange buildings which the white men were erecting, so on March 22, 1622, when the blast furnace was to start operating, the Indians swooped down on the settlement and massacred all but one man. The Indians completely destroyed the iron works, which was never rebuilt.

The first successful ironworks built in this country was in Massachusetts on the banks of the Saugus River, halfway between Boston and Salem. It is believed to have included a small blast furnace to smelt iron ore into liquid iron for castings, and a forge to refine the iron from the furnace into ductile wrought iron. Late in 1644 the first iron was produced, and the first object cast, which was a cooking pot. Mount Joy Forge, which later became the Valley Forge of the Revolutionary War was a foundry, established in 1742. Among the wellknown names in Colonial foundry history is that of Paul Revere, who operated a bell and cannon foundry near Boston, which later became the Revere Copper and Brass Company. The first cupola appeared in the United States about 1815, but it was not until about 1850 that the drop bottom to the cupola appeared. Colonial foundrymen were active in the Revolutionary cause and because of this they improved many of their techniques to speed up production. The industry, from its single foundry engaged in the manufacture of cooking utensils at Lynn, Massachusetts, has developed into the fifth largest industry in the United States. There are 6,208 foundries producing an enormous tonnage of castings of an unlimited variety.

Modern Foundry Industry. Today, castings are required as component parts or as end products in ninety per cent of all durable goods produced. Some of the very large industries that are dependent upon these castings are the automotive industry, the machine-tool industry, transportation industries, plumbing, sanitation, heating, and home-appliance manufacturing. Some others are electrical equipment, mining, and agriculture equipment. Today in this country, gray-iron foundries number 2,729, and produce 13,860,527 net tons per year. The malleable-iron foundries number 130, and produce 951,868 tons per year. There are 452 steel foundries and they produce 1,931,987 net tons per year. Brass and bronze foundries number 2,728, and produce 966,306 tons per year. There are 3,355 aluminum foundries and they produce 794,581 net tons per year. Other non-ferrous foundries number 1,057 and produce 729,896 net tons per year. The total number of foundries in the United States today is 6,208 and they produce about 19,235,165 tons per year. The estimated net tonnage for these foundries by 1960 is 21,000,000. The foundry industry employs over 500,000 people and more than half of the foundries employ less than fifty people. Modern civilization would not be so far advanced as it is today if it were not for the foundry and its products. The foundry industry is a progressive one, always looking ahead, and, as it improves and progresses so will civilization.

History of the Foundry in Schools. The first schools to introduce foundry as a part of their curriculum were the German schools at Charlottenburg and Darmstadt about 1700. These were technical universities and were under the direction of German industries. France began their technical schools about 1747 and foundry theory classes were part of the curriculum for the military and civil engineers. The creation of the United States Military Academy, at West Point, in 1802, and the Rensselaer Polytechnic Institute in 1824, marks the American beginnings in technical education. Probably not in the beginning but early in the history of these two schools, foundry theory is mentioned in the curriculum. From these, foundry has spread to nearly every large university in this country.

In the next chapter the writer presents the history and philosophy of industrial arts. The chapter will also list some suggested objectives for the industrial arts program in the junior high school.

CHAPTER III

HISTORY AND PHILOSOPHY OF INDUSTRIAL ARTS

The industrial arts division of today's education program is directed to the study of industrial tools, machines, materials, and processes through the objectives of general education. Todays industrial world is dependent upon foundry as an integral part of industry. The art of metal-casting is an industry in itself. The place of foundry in education becomes apparent if this fact is accepted.

PART A

History of Industrial Arts

The teaching of industrial arts must fit into the overall program of the school. Industrial arts is devoted to the objectives of general education. The history of the various movements that were responsible for the philosophy of industrial arts are presented in the interest of establishing the objectives of industrial arts.

Primitive Education. The object of primitive education was the development of hand skills. If the early man was without these skills, he had no means of providing the necessities of life. Through his hand skills, he could fashion weapons for killing food and for protection; he was able to provide clothing and shelter for his family. This primitive education was the responsibility of the father and was learned by unconscious imitation through association in the home or tribe. Without this skill, the necessities of life were not obtainable and survival would have been doubtful. Hand work was the essential thing in primitive education. (3, page 11)

Early History in Europe. The ancient Jews believed that a boy should be taught a trade, as well as religion. The Jewish law placed the responsibility of teaching the trade on the father. As a result of this, each boy was sent to school for the Rabbi's instruction each morning; and the afternoons were spent with the father, learning the father's trade. The early Christian monks and the Benedictines required manual labor as part of their teaching of religion. Certain hours were assigned to study and religious practices, and other hours were set aside for labor. The production of books became the responsibility of the monks. New crafts and skills were developed to facilitate the production of books. The monastic schools were the primary source of education until the Sixteenth century. (3, page 14)

Luther. (1483-1546), a great reformer during the sixteenth century, advocated the following:

> The right kind of schooling should be given to all the people, noble and common, rich and poor; it was to include all the boys and girls. The state was to use compulsion if necessary. (3, page 31)

This was taking place in Germany because Luther was against the monastic and ecclesiastical schools. At the same time Rabelais, in France, began to disagree with the shallowness, formalism of the church, school and state.

Rousseau. (1712-1778) Rousseau, a French philosopher of the eighteenth century, recognized that hand skills were necessary for young men. He believed that a trade involving hand skills was a safeguard against personal want and poverty. He urged systematic instruction and training in some form of manual industry. He believed in adjusting education to the natural impulses of the child.

Pestalozzi. (1746-1827) Pestalozzi, known as the father of industrial arts, was the first man to establish work as a regular part of a school program in his many schools and repeated the successful use of manual labor, both skilled and unskilled. His process of teaching from real objects took the pupil into fields and shops, demonstrating the understanding of the skills desired. Although Pestalozzi never used actual tool instruction, his drawing and form study were definitely in the industrial arts field. As a result of his industrial school, established in 1774, many such schools were founded in all parts of Europe. (3, page 119)

Froebel. (1782-1852) Froebel, a pupil of Pestalozzi, took another step in the direction of eliminating meaningless study and establishing the idea of self-activity. Froebel felt that children are creative and receptive and express themselves in action. He thought that education should come from things which the child knows, things which are a real part of his life. Froebel made the following statement regarding a proposed school:

> The institution will base its work on the pupil's personal efforts in work and expression, making these, again, the foundation of all genuine knowledge and culture. Joined with thoughtfulness, these efforts become a direct means of instruction, and thus make of work a true subject in instruction. (3, page 164)

Fellenberg. (1771-1844) Phillip Emanuel von Fellenberg, believed that each individual should be prepared to live a happy life, but that each class of people should be taught separately. Every man should be educated for his own sphere. In 1799 Fellenberg, along with Pestalozzi, established the institution of Hofwyl. Manual labor was used at Hofwyl for physical training as well as for practical experience. Because of contrasting personalities between Fellenberg and Pestalozzi, the school failed. Later, Fellenberg established an academy by himself.

Fellenberg Academy. Fellenberg believed in the slow process of starting a school. He began his Academy by taking in a few poor boys and providing for them. Later, a building was built for the well-to-do boys. This school included instruction in Agriculture, science, and manual labor. In the Fellenberg farm and trade school the boys were fed mostly vegetables, which they grew, and clothed like farmers. The program taught by instructors was as follows:

> While working with them in the field, he told them instructive stories, and gave them problems in arithmetic to solve. He explained the properties of the soil which they were working, led them to examine it in regard to its composition, weight, chemical action, and its capacity to their attention to the characteristics of the plants which they found, explained to them natural phenomena, and in connection with the laying out of

plots in the fields he made them familiar with some of the fundamental principles of geometry. (3, page 135)

This was not the only school Fellenberg had. There was many more, such as Fellenberg's school of applied science, Fellenberg's school for girls, and Fellenberg's normal school. From these schools foundations were laid for more schools in Europe.

Apprenticeship. The practice of apprenticeship was brought about when the workers developed crafts into specialized skills and trades. The father was supposed to be the first teacher of skills in hand work. Later, the religious schools taught trades and crafts. As the need for skilled labor became apparent, new and better methods were sought to broaden education and produce more and better skilled labor. Education was acquired through an apprenticeship. The master gave the boy instruction in moral, religious and civic needs, in addition to teaching the skills of a trade or craft. Apprenticeship was the chief source of education until the Nineteenth Century. (3, page 21-22)

PART B

Development Of Industrial Arts In America

The development of industrial arts in America, as well as many of the social traditions, was greatly influenced by the changes as they took place in Europe. The idea of free education which prevailed in the colonies offered a better educational opportunity for all social classes.

Colonial. The first school in America seems to get its foundation not from merely local conditions but from Europe. All legislations and ordinances, provided by the colonists concerning education during the seventeenth century, come from customs and laws in England.

The apprenticeship method of instruction carried on in the English Colonies was almost the same as that practiced in England. Since the apprenticeship was under the control of town and colony authorities, and because there were no guilds, it developed more as an educational institution. Legislation was passed by most of the Colonies for the benefit of the apprentice. There were faults in the American apprenticeship's instruction just as there were in Europe. Even though many of the masters were skilled in their trade, they could neither read nor write. This led to the establishment of the first elementary school in America.

In 1647, the General Court of Massachusetts issued an order that for every town of fifty families they had to select a teacher to be paid by the inhabitants of that town. The most important outcome of this court order was the establishment of the "free" schools in America.

In 1685, Thomas Budd of Pennsylvania and New Jersey, proposed a plan for public education in those two states. This plan called for compulsory education for all children, the rich, the poor, and Indians. Budd proposed to teach each child that "art, mystery, or trade that he or she most delighteth in." (10, page 12) There is no evidence that his plan was ever put into practice, but it may have had some influence on education of that day.

One of the most notable schools established during the eighteenth century was De La Howe School at Abbeville, South Carolina, founded in 1787, and attended by both girls and boys. The boys were primarily engaged in farming and gardening, while the girls practiced the household arts.

Industrial Schools Of The Early Nineteenth Century. The Mechanic's Institute movement of England moved to America in 1820 with the forming of the General Society of Mechanics and Tradesmen of the City of New York. The Society opened a library for apprentices and formed a mechanics school. The Franklin Institute of Philadelphia was incorporated four years later. The course of study in this school consisted of English, classical studies, modern languages, and mathematics and practical sciences. In the same year 1824, Stephen von Rensselear established the Rensselear School at Troy, New York. This was the first engineering school, and the first graduate school in America.

The Land-Grant Act of 1862. The land grant act grew out of a demand for higher places of learning where science and practical sciences could be combined. Justin S. Morrill, a member of the House of Representatives, presented the bill three times before it finally became law. The first time it failed to pass the Senate, the second time it was vetoed by President Buchanan, but the third time it was signed by

President Lincoln and became effective July 2, 1862. By the terms of this act, 30,000 acres of public lands was granted per senator and representative in Congress for the purpose of providing agriculture and mechanical colleges.

With the Second Morrill Act of 1890 and the Nelson Admendment of 1907, the original grant has been supplemented by an appropriation of $50,000 a year to each state, and Puerto Rico.

Woodward. Calvin Milton Woodward was a mathematics instructor, who became known as the "great champion of manual training." When he realized how little his engineering classes knew about tools and their use, he became a shop teacher. Students upon graduating were having to spend around two years in apprenticeship before they could find jobs because they knew nothing about the practical side of engineering. This led Dr. Woodward to advocate shopwork as a part of the engineering courses. As early as 1873, Dr. Woodward was advocating the teaching of hand work as a part of general education. Under his influence, a new movement was developing in St. Louis. After the Centennial Exposition, he was instrumental in establishing a school of manual training. Although contrary to his belief, he was forced to make the school mostly vocational in order to raise the necessary funds. This school resembled the Russian System very much, and this was what was said about it:

> In the St. Louis School, the teaching of mechanical processes was carried on through a media of exercises and models of some intrinsic value but frequently lacking in boy interest. (9, page 46)

Later through the influence of "manual arts" and the sloyd movements, articles of more interest were included in the course of study, but many of the exercises were retained.

Runkle. Dr. Runkle was president of the Massachusetts Institute of Technology when he attended the Centennial Exposition in 1876 and there for the first time saw the Russian system exhibited. He was very much impressed and decided that it was what his school needed. Upon returning, he recommended that the Institute establish shops for instruction in the mechanical arts. He also later formed a new secondary school for those who wished to enter industrial pursuits rather than be engineers.

Manual Arts. When manual training first began, little attention was placed on the artistic quality of the students work. More emphasis was placed upon ability of the student to perform manipulative tasks and develop an appreciation of industry. The appreciation of good design and beauty was considered to be beyond the scope and purpose of manual training. In the latter part of the Nineteenth Century and the early part of the Twentieth Century, there was a gradual change taking place in the emphasis placed on manual training. Because of this change, the emphasis in manual training shifted from the purely mechanical aspects to the consideration of arts and in allowing the pupils to select and design their own projects. This was the beginning of the newer manual arts. Charles Bennett, who promoted the expression "Manual Arts" since 1894, classified these arts into these five groups: graphic, mechanic, plastic, textile, and bookmaking arts. (5, page 16)

Manual Training. The manual arts movement is not easily distinguishable from manual training. The manual training movement did, however, result in two major contributions to educational shopwork; the project method, and a larger variety of shop subjects. The extension of shopwork into fields other than wood and metal work provided a better opportunity to acquaint the student with industrial life and its problems. (9, page 47)

Industrial Arts. Industrial arts, as a study of industry, falls well within the limits of general education since industry has become a very important part of our culture. Industrial arts is considered a part of general education not because of an indefinite "general" nature and not because it studies subjects which are accepted as general education subjects. Instead, industrial arts is a part of general education because it gets its subject matter from industry, and because it gives a greater understanding and better control of the phenomena of industry. As a part of general education, industrial arts does not have a set of objectives which it alone supports. It does make good contributions to objectives which are common to the entire school program. Industrial arts is basically a shop or laboratory subject area; it emphasizes the use of material things and the problem solved usually results in something the student can see. It provides for extensive expressional opportunities, and provides experiences in which the learning takes place through the sense of feeling or touch and also by seeing and hearing. It is a class which can follow informal patterns, and it derives its content from the world of work. It is obvious some of these features are shared with the physical sciences, some with the social sciences, and some with the arts. The following are objectives associated with an industrial arts curriculum and are points of emphasis rather than boundaries for the subject.

Suggested Objectives for Industrial Arts. Nine objectives, common to industrial arts, are presented in summary form below. They should be considered merely as suggestions, however, because each industrial arts teacher should develop his own objectives in light of his philosophy of general education, the needs of his students, and the available facilities.

1. Interest in Industry. To develop in each pupil an active interest in industrial life and in the methods and problems of production and exchange. Young people are alert and curious as to what goes on about them, and many present-day homes and communities do not afford real opportunities for observing and understanding industrial life and its problems and opportunities. The schools and, particularly, the industrial arts teachers must aid in filling this gap. (2, page 19)

2. Appreciation and Use. To develop in each pupil the appreciation of good design, materials and workmanship and the ability to select, care for and use industrial products wisely. They should be aided in developing thoughtful attitudes about the avoidance of waste and about how to secure the greatest possible service from the things they own. (2, page 20)

3. Self-Realization and Initiative. To develop in each pupil the habits of self-reliance and resourcefulness in meeting practical situations. We have unusual opportunity to build self-confidence, judgment,

self-discipline, idealism, reliability respect for authority or valid custom, ingenuity or self-expression. (2, page 22)

4. <u>Cooperative Attitudes</u>. To develop in each pupil a readiness to assist others and to join in socially-accepted group undertakings. School is the place to impress the fact that harmony is a requisite of happy home and community life, and that good attitudes are highly conducive to advancement in most earning situations. (2, page 23)

5. <u>Health and Safety</u>. To develop in each pupil desirable attitudes and practices with respect to health and safety. Information provided and habits established will be certain to have observable effect in the school shop and to have carry-over to home and working life. (2, page 24)

6. <u>Interest in Achievement</u>. To develop in each pupil a feeling of pride in his ability to do useful things and to develop certain worthy free-time interests, particularly in the crafts. (2, page 25)

7. <u>Habit of Orderly Performance</u>. To develop in each pupil the habit of an orderly and efficient performance of any task. We want to develop in our pupils the habits of thoughtful, careful work of any kind and the forsaking of loitering and waste. If these habits are to be established, there must be conscious effort to this end. Industry, productivity and dependability in connection with tasks are qualities that insure personal worth, regardless of the occupation pursued. (2, page 26)

8. <u>Drawings and Design</u>. To develop in each pupil an understanding of all kinds of common graphic representations and the ability to express ideas by means of drawings and sketches. There must be controlled observation with reference to line, spacing, symmetry, setting, usefulness, strength, color and similar factors. (2, page 27)

9. <u>Shop Skills and Knowledge</u>. To develop in each pupil skill in the use of common tools and machines, and an understanding of the problems involved in common types of construction and repair. (2, page 28)

The school is basically a behavior-changing institution. That is, school experiences make the pupils different than they would be if they lacked these experiences. The experience the pupil has in a school shop foundry is essential in understanding more fully the processes and techniques of this industry. In the following chapter these processes and techniques will be discussed.

CHAPTER IV

THE SCHOOL FOUNDRY

In preparing this report, it has been the author's desire to provide a suitable guide for junior high school shop instructors. The report is elementary to the extent that the student can grasp the fundamental principles of foundry work, yet deep enough to give a general working knowledge of foundry practices.

Foundry Layout. When planning the layout for a foundry, take into consideration the number of pupils that are going to use it each period. It is recommended that space be provided for not more than three or four pupils. With this number of pupils the shop would not have to have a large quantity of molding sand or tools. There is also a safety factor present with only a few working in this space.

The area should be well ventilated and lighted. An exhaust fan is recommended because of the heat and dust that is always present in a foundry. A partition or low wall should enclose the area. This is to keep the sand from being tracked out into other parts of the shop. An I-beam about six inches high, enclosing the area, is very good for this purpose.

Foundry Sand. The composition of molding sand as given by some chemists is: 80 to 90 per cent silica, 6 to 10 per cent alumina (clay), and small percentages of other ingredients such as lime, magnesia, and metallic oxides.

The selection of good molding sand is very important to the successful making of good castings, because you must have sand suitable for the particular class of castings you want to make. For small castings, requiring a smooth surface, a molding sand of fine grain must be used. When heavy castings are to be made, a sand of coarse grain is required to allow the steam and gas to pass out of the mold freely while the metal is solidifying. The sand must be rammed harder for large castings than for small ones. If a sand suited for light castings is used for heavy castings, there is danger of scabbing, and at times the metal may be blown out of the mold, since the steam and gases cannot escape.

Tempering Sand. Sand is prepared for molding by cutting and tempering. Cutting the sand is simply mixing it to break up lumps and distributing it so that there are no dry places in the pile or bin. Tempering is accomplished by adding dry sand to decrease the moisture content or by adding water to increase the moisture content. Moisture should be added only when necessary.

Procedure:

1. Test the sand for dampness by grasping a handful and squeezing it into a lump.

2. Break the lump. If the edges of the broken surface remain sharp and firm, the sand contains sufficient moisture and is ready for use. If the edges break and crumble, and

the lump falls apart, the sand is too dry. If the sand makes the hand muddy or if the sand feels soggy, it is too moist.

3. If the sand is too dry, add a little water with a sprinkling can.

4. Starting at one end of the pile, shovel the sand over, mixing it well and breaking up the lumps with the back of the shovel. Repeat this operation two or three times.

5. When the sand has been mixed thoroughly, test for moisture as described in step 1. Continue until the sand has the degree of moisture desired. Be sure not to get the sand too damp as wet sand will cause blow holes in castings.

6. If the sand is too moist, sprinkle a few shovelfuls of dry sand over the pile and cut as in steps 4 and 5.

Care of Sand: When the sand is in use every day, it is likely to become weak, causing a great deal of trouble, not only in making molds, but also because the sand will wash when the metal is poured. After it has been used many times, the sharp edges have become rounded, partly from wear and partly from the high temperature of the molten metal, and the clay has burned out. These changes are the main causes for the weakening of sand in use. New sand, that is, sand that has not been used for molding, is stronger than it need be, and when added makes up for the weakening of the old sand. In this manner, sand may be used over and over without a complete replacement at any time. After the sand has been used for a time and is somewhat burned, it will give better results than when new. Generally speaking, castings made in old sand, or sand partly burned, will have a smoother surface than those made in all new sand.

Molding Tools: Many types of tools and appliances are used in making molds. The selection of tools depends upon the shape and size of the castings to be made. Only such tools as are needed in this course will be discussed.

Shovel: The shovel is indispensable. It should always be kept clean, not only to protect it from wear but also because a clean shovel can be handled more easily and rapidly than a dirty one. A rusty shovel, or one coated with sand, is a very clumsy tool.

Bellows: This instrument is used by the molder to blow loose sand from the recesses of the mold. Bellows may be had in 9, 10, 12, and 14 inch sizes. A 10 inch bellows is large enough for general purposes.

Bench Rammer: This is the device the molder uses for packing the sand in the flask. The large, round part is called the butt, and the wedge shaped part is the peen. Bench rammers are made of hardwood, usually maple. They range in diameter from three inches to five inches and are fourteen inches long.

Dust Bags: The dust bag is used by the molder to hold the parting or parting compound which is dusted onto the face of the mold. Dust bags may be secured for fine or coarse facing material.

Straightedge: The straightedge is used to cut the sand level with the flask, after the mold is rammed.

Draw Pin: A draw pin or draw screw is a device used for drawing the pattern from the mold. Whenever practicable, the use of a draw screw is recommended.

Crucibles: These are devices used for holding metal while it is being reduced to a liquid state. Crucibles usually are made of a combination of graphite and a special clay. Before a new crucible is put into service it should be gradually brought to a temperature of 250 degrees Fahrenheit and held thus for several hours. Before starting to load a crucible, be sure it is dry. If a wet crucible is put into a hot furnace, the crucible is almost certain to crack. A crucible should not be left in the furnace after the metal is ready to pour. Metal should never be left in the crucible to cool, but should be emptied into an ingot mold or into a depression in the sand. After the metal has been poured, the crucible should be allowed to cool slowly. Quick changes in temperature will cause the crucible to flake or crack.

Flasks: Flasks are of two kinds, snap and solid. The solid flasks are recommended for the school shop. Flasks are made rectangular, square, or round, and come in a number of sizes.

Riddles: This device is used by the molder to remove foreign matter from the sand and to insure the depositing of a coating of fine sand on the surfaces of the pattern. Riddles are made of woven brass or galvanized wire. The size of a riddle is given in inches in diameter and the number of openings per lineal inch. For general purposes, a 12 or 14 mesh riddle is recommended.

Sponges and Swabs: The bulb sponge and the swab are devices used for moistening the sand at the parting line adjacent to the pattern or elsewhere in the mold as occasion requires.

Sprue Cutters and Gate Cutters: These tools are used for cutting a passageway in the sand along which the metal travels on its way to the cavity in the mold. The tapered sprue cutter is used to make an opening for the metal so that it can pass through the cope part of the mold. The gate cutter is used to cut a passageway through the sand in the drag from the sprue gate to the cavity in the mold.

Trowels, Slicks, and Lifters: Trowels and slicks are tools used to smooth, patch, and finish molds. Trowels are used principally for smoothing and patching large surfaces, while slicks are used to smooth and patch grooves in small breaks. Lifters are used principally for lifting particles of sand from deep narrow recesses and for making small repairs in restricted spaces.

Ramming The Sand: The sand must be rammed solidly within the flask and around the pattern. It must be rammed firmly enough to withstand the flow and pressure of the molten metal and hard enough so that the mold can be handled without having the sand drop out of the flask. With soft ramming, the casting is likely to be larger than desired. If the mold is soft in spots only, the casting may have bulges or lumps. Sand must not be rammed harder than is necessary, becuase the denser the sand, the less chance the steam and gas have to pass through it, and because too hard ramming will cause blow holes in the castings and scabs on them. There is no way to learn how hard to ram a mold except by actual practice.

Venting The Mold: Since considerable air, steam, and gas are in all molds, these must be driven out through the sand when the mold is poured, else the castings will probably be full of blow holes. Blow holes are usually found in the part of the casting that is highest when the mold was poured. Air is found in all molds. Steam is formed when the hot metal is poured into damp molds. When fluid metal comes into contact with a mold, the sand next to the metal is heated to a very high temperature and a rapid chemical reaction takes place. This reaction liberates gases from the sand, some of which pass into the open spaces in the mold. If they do not escape quickly, they will be caught and enclosed by the metal or pass to the top of the mold and prevent the metal from filling the mold completely.

When the ramming is done properly and a porous sand is used, the steam, gas, and air will pass out of the mold between the grains of the sand. Almost all molds, however, must be vented, which means that vent holes must be punched into the sand to afford the steam, air, and gas free passage out of the mold.

Facing The Molds: Small or thin castings can be made successfully and with a fairly smooth surface if the metal is poured into molds that have not been faced. If the molds are faced, however, the castings will usually be smoother. The facing materials most used for producing small castings are Ceylon lead, East India plumbago, and soapstone or talc. Portland cement, which is much more economical, can also be used for a facing material. These facing materials ordinarily are put into a small bag, and after the patterns are drawn from the sand and the gates cut, a thin layer of the facing material is dusted onto the surface of the mold with the bag. Rubbing the facing on the surface of the mold with the hand, or brushing it down with a camel's-hair brush, will give a much smoother surface than that obtained by simply shaking on the facing and leaving it as it falls. When very smooth castings are wanted and the mold has small projecting parts of sand likely to be knocked off if the mold is touched with a brush, the pattern may be replaced in the mold after the facing has been dusted on and tapped down. The facing is thus pressed into the sand and the pattern is then withdrawn. This process of facing a mold is known as the "printing-back method."

OPERATION SHEET

Bench Molding

Objective:

1. To gain experience with the tools and materials needed in bench molding.
2. To experience the procedure of making a green sand mold.

General Information:

Making a sand mold involves a proper packing of molding sand around a pattern. After the pattern is removed from the sand and the gating completed, the mold cavity is filled with molten metal to form a casting. Sand with a clay-type binder that is used in a moist condition is called green sand. Green sand molds are usually poured soon after they are made.

Tools and Materials:

1. Set of hand tools including rammer, slick, sprue pin, vent rod, draw pins, gate cutter, swab, and some parting dust.
2. Suitable flask, molding board, and bottom board.
3. Shovel, riddle, and strike-off bar.
4. Supply of molding sand.
5. Selected pattern.

References:

Metalwork and Technology, McGraw-Hill Book Company, Inc.
New York

Procedure:

1. Check over all tools and equipment and report any damage.
2. Temper a supply of green molding sand.
3. Place the drag and molding board.
    a. Place the molding board on bench.
    b. Place the drag on the board, pins down.
    c. Determine gating requirements.
        (1) The gating is a system of openings through which the molten metal flows to the cavity.
        (2) Metal should reach the cavity with a minimum of disturbance and cooling.
    d. Place pattern on the molding board with wide face down.
4. Make the drag.
    a. Riddle sand to a depth of about one inch over the pattern.
    b. Press sand into any irregular surfaces, cavities, or other pattern details.
    c. Finish filling the drag with sand.
    d. Ram the sand with the peen end of a rammer.
        (1) Avoid striking the pattern with the rammer.
        (2) Start ramming around the edge and then through the center area.
        (3) Ram the sand just firm enough so that it will hold together. Overramming will reduce openness of sand, and underramming will cause a weak mold.
    e. Refill drag heaping full, finish peen ramming, and butt ram over the surface.
    f. Strike off excess sand so that it is level with sides of the drag.

g. Vent with a vent rod if required.

h. Sprinkle on loose sand and place bottom board on the drag.

i. Roll this assembly over.

j. Remove the molding board.

5. Make the cope.

a. Inspect the parting line and make adjustments.
   (1) If split pattern is used, place the cope half of the pattern in at this time.

b. Place the cope on the drag.
   (1) Be sure pins and sockets fit snugly.
   (2) Be certain cope is right side up.

c. Place sprue pin in position and plan for sprue cutter.

d. Apply parting compound over surface.

e. Riddle facing sand, tuck details, add more sand, and ram as was done when making the drag.

f. Remove the sprue pin and make a pouring basin.

g. Remove sand from floor around work bench.

6. Finish the mold.

a. Lift the cope from the drag, roll it so that the parting face is facing the molder.

b. Bevel the edge of the sprue hole at the parting line.

c. Moisten sand around pattern with swab.

d. Insert rapping pin and loosen pattern.

e. Draw pattern out of sand.
   (1) When drawing pattern, shake slightly to insure a free draw.
   (2) Draw pattern as straight as possible to avoid damaging cavity edges.

f. Repair the mold cavity if necessary.
   (1) Slick carefully away from cavity edges.
   (2) Patch larger area by pressing sand onto point of slick and then into position.

g. Make the gates and runners.
   (1) Use gate cutter to form a U-shaped opening from cavity to point of sprue at the parting line.
   (2) Number and size of gates varies with size and shape of cavity.
   (3) Cut runners deeper directly under sprue.
   (4) Form a restriction (choke) in runner near cavity.
   (5) Be sure runner and gate surfaces are smooth and clean.

h. Remove any loose sand and foreign particles from cavity, gate, and runners.

i. Inspect mold carefully and set cores if required.

7. Close the mold.

   a. Roll the cope so that parting line is down.

   b. Inspect the sprue and, if necessary, clean sprue.

   c. Position cope over drag and carefully close the mold.

   d. Place mold, on the bottom board, on the floor.

8. Pouring the Mold.

   a. The instructor will pour all molds.

   b. Select a pouring ladle and inspect it. Avoid using a ladle that is cracked or has a loose handle.

c. Obtain a supply of molten metal from the furnace.

d. Approach your mold and position yourself in a comfortable position with bowl of ladle near mold-pouring basin.

e. Pour mold with a steady stream of metal.

f. After a waiting period, remove the cope and dump molds into sand heap.

g. <u>Casting will still be hot</u>. Handle only with tongs.

9. Clean up.

a. Return all tools to proper place, clean and reassemble flask, clean bench, return patterns to proper place, and sweep floor around your work space.

b. After clean-up, cool the casting and place it out for instructor to evaluate.

10. Evaluation.

a. During evaluation, fill in small report except for grade.

OPERATION SHEET

How To Make A Sand Core

Objective:

1. To experience the procedure of making a sand core.

General Information:

A high silica sand is used for making cores. To give strength, this is mixed with a suitable binder such as linseed oil or a core compound.

Tools and Materials.

1. Small quantity of core sand.
2. Suitable binder.
3. A split core box and a flat core box.
4. A vent rod and C-clamp.
5. A core pan and bake oven.

References:

Metalwork and Technology, McGraw-Hill Book Company, Inc. New York

Procedure:

With A Split Core Box

1. Secure a small quantity of clean core sand.
2. Measure by volume 30 to 40 parts of sand to one of binder and mix with the hands thoroughly. If a commercial core compound is used, follow directions on the container.
3. Secure the core box desired and dust thoroughly.

4. Dust a little parting compound on the working faces of the box.
5. Place the core box on the bench. If it is a split box, clamp it together with a C-clamp.
6. Place the box on end, fill the cavity with sand and pack it firmly with the fingers or rather lightly with a dowel or round rod. Strike off the sand even with the top of the box with a straightedge.
7. Vent the core by running a vent rod through the center.
8. Rap the box lightly with a light mallet, then remove the clamp.
9. Hold the core box in a horizontal position, then remove that part of the box which contains the dowel pins.
10. Place the edge of that part of the box, which contains the core, against the edge of a core plate. Tip the box slightly and allow the core to roll out gently.
11. Place the core in a core oven and bake brown. A small core will bake in an hour or two. An old bake oven placed over a gas plate or furnace will serve for this purpose.

With A Flat Core Box

1. Fill the box with core sand and pack it with the fingers.
2. With a straightedge, strike off the sand even with the face of the box.

3. Vent the core by piercing it in several places with a vent rod.
4. Rap the box lightly with a mallet.
5. Place a core plate on top of the box, then turn both plate and box over.
6. Rap the box lightly, then slowly raise it, leaving the core on the plate.
7. Place the plate and core in the oven and bake until brown.

OPERATION SHEET

How To Set A Core In A Mold

Objective:

1. To experience the procedure of setting a core in a mold.

General Information:

The purpose of a core is to form a recess or an opening in a casting. A core may be very simple or it may be very complex. Generally, small castings have but one or two simple cores, if any. There are many ways of setting cores, but only the most common and simple of these will be described.

Tools and Materials.

1. Core or cores that have been properly baked.
2. A mold that has been rammed up and is ready for pouring.

References:

Metalwork and Technology, McGraw-Hill Book Company, Inc. New York

Procedure:

Setting A Vertical Core

1. Secure the desired core and brush away all loose sand.
2. File a very slight taper on the drag or straight end of the core if cylindrical, or on the bottom edges if the core is flat.

3. Carefully place the core into position in the recess made by the core print, being sure it is vertical.
4. Close the mold in the usual manner.

Setting A Horizontal Core

1. Secure the core desired and brush away all loose sand.
2. Hold the core over the recesses made by the core prints and test for length.
3. If the core is too long, file away a little sand at one end.
4. Carefully place the core in the recesses made by the core prints.
5. Close the mold in the usual manner.

No one who studies the foundry industry can fail to be impressed by the tremendous scope and importance of the foundry product. Perhaps the vast importance of the foundry industry might better be emphasized if each one of us would attempt to imagine, for a moment, a world without cast metals. Such a world as we know it today would not exist. It is the responsibility of the casting industry, as well as those who use its products, to preserve and to advance it for the benefit of all mankind.

CHAPTER V

CONCLUSION AND RECOMMENDATIONS

This report was undertaken by the author because he felt the need for more information concerning a course of study in foundry. Since America today is essentially industrial in nature, our schools must provide a general education which makes for understandings and appreciations for the society in which the student must soon take his place. Foundry, as a part of industrial arts, makes it possible for the individual to become acquainted with a broader range of materials and processes

Conclusion. The purpose of this study is to aid industrial arts teachers who are seeking information on foundry as a unit in their shop. The course should be designed to acquaint the student with a fundamental working knowledge of foundry and the use of tools, materials, and equipment related to the subject. A basic experience in foundry will help the student realize more the importance of foundry in this industrial society. With these points in mind, the writer believes that a unit in foundry should be offered in the junior high school.

Recommendations. A future study could be made and a course of study in advanced foundry for senior high school, with more emphasis placed on patternmaking and related fields.

SUGGESTED AUDIO-VISUAL AIDS

The instructor who wishes to use audio-visual aids may contact his state university film library or other film-distribution centers for films and film listings, or he may write directly to the individual producers listed below.

16 mm, Sound, Motion-picture Films

1. Charging and Operating a Cupola. U. S. Department of Commerce, Office of Technical Services, Washington 25.

2. Die Casting. The New Jersey Zinc Company, 106 Front Street, New York 38.

3. How Else Would You Make It? American Zinc Institute, Inc., 60 East 42d. Street, New York 17.

4. The Matter of the Core. Osborn Manufacturing Company, 5401 Hamilton Avenue, Cleveland 14.

5. Mechanization in Molding. Beardsley and Piper, Division of Pettibone-Mulliken Corp., 2424 N. Cocero Avenue, Chicago 39.

6. Preparing A Cupola for Charging. U. S. Department of Commerce, Office of Technical Services, Washington 25.

7. Quality Castings for Industry. Textile Machine Works, Foundry Division, Reading, Pa.

8. This Moving World. Malleable Founders Society, Union Commerce Building, Cleveland 14.

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