A STUDY OF THE FOUNDRY METALS IN THE HIGH SCHOOLS IN TEXAS

THESIS

Presented to the Graduate Council of the
North Texas State University in Partial
Fulfillment of the Requirements

For the Degree of

MASTER OF SCIENCE

By

Jerry L. Underhill, B. S.
Denton, Texas
August, 1977

Jan

Underhill, Jerry L., A Study of the Foundry Metals in the High Schools in Texas. Master of Science (Industrial Arts), August, 1977, 63 pp., 11 tables, 5 illustrations, bibliography, 9 titles.

The problem of this study was to determine the type of metals used in the foundries in the high schools of Texas and the treatment of these metals. The data for this study were provided by thirty metalworking instructors of Texas high schools.

Of the Texas high schools offering foundry as part of their metalworking curriculum, all included aluminum as a basic metal. In addition, the amount of metals used and their treatment varied from school to school.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

CHAPTER I

INTRODUCTION

The earth has been blessed with an abundance of raw materials man can use. Throughout the world are found vast forests, deposits of oil, coal, iron, and other needed minerals. "It is said that about one-sixth of the earth's crust is aluminum ore, but it is difficult to extract the pure metal" (7, p. 161).

Man has been using some of these resources since the beginning of civilization. At first, the methods of processing these materials were somewhat crude, but through the years new and different processes and procedures have been refined. From the beginning of the industrial revolution to the present, new technologies, materials, and scientific discoveries have brought constant change in the way in which man lives.

Many metals in their pure state are too soft and lack the high strength necessary for them to be used effectively. It has been discovered that by combining two or more metals, a new and different metal is formed. This combination of metals is commonly referred to as forming an alloy.

The content and method of industrial arts instruction reflect the numerous changes and technological developments found in today's industry. By definition, industrial arts is a "study of industrial materials, products, and processes through meaningful laboratory experiences" (3, p. 20).

A large portion of industry today involves metal working. Because foundry is an important part of the metal working industry, emphasis should be placed on this instructional area of industrial arts.

Statement of the Problem

This study was designed to determine the types, sources, costs, storage requirements and the treatment of metals used in high school industrial arts foundry programs in the state of Texas. In this study, answers to the following questions were sought.

1. What types of metals are processed through high school foundries?
2. What types of storage facilities are utilized for metals?
3. What treatment do the foundry metals receive?
4. How much new metal is used?
   A. What types of alloys and shapes are used?
   B. Where is the metal obtained?
   C. At what prices are metals obtained and sold?
5. How much scrap metal is used?
   A. What types of alloys and shapes are used?
   B. Where is the metal obtained?
   C. At what prices are the metals obtained and sold?
6. What types of problems exist when pouring castings?

Background and Significance of the Study

The United States is beginning to realize a shortage of many of its natural resources. The current energy crisis is making ever more apparent an urgent necessity that something be done to conserve existing supplies. The present way-of-life must change within a few years unless something is done to curtail wasteful practices.

Much concern is being voiced regarding ecology and the possibility of recycling materials normally thrown away or destroyed. Often new products can be produced from recycled materials at a cost which is less than that of developing them from raw materials. This recycling conserves energy which can then be redirected to other needs. Several aluminum producers, including Kaiser and Alcoa, now have programs for recycling aluminum products. Alcoa stated,

> Good news. Recycling's really working. In 1975, the people brought in over three and a half billion aluminum beverage cans for recycling. Those who collected the cans were paid twenty-four million dollars in cash for their efforts. Recycling is important because it saves 95 per cent of the energy needed to make new metal from bauxite. Closing the energy loop is paying off in more ways than one. Recycling works (1, p. 39).

Some of the practices that industry uses to conserve energy and to cut production cost can also be used to cut the educational cost.

Educational costs have sky-rocketed during the past few years. Such rises in expenses have necessitated the search for ways to reduce expenses for school districts as well as for students. Expensive laboratory equipment and student supplies make the field of industrial arts an especially costly area of education. The foundry area of the metals program can be costly unless ways are found to reduce material costs.

Limitations of the Study

Factors limiting the scope of this study included the following.

1. This study was limited to only those senior high schools in the state of Texas that offered units of foundry in their metals curriculum.

2. The study was further limited by the number of instructors completing and returning the instruments.

Definition of Terms

Terms of special importance to this study are defined as follows.

Alloy.--An alloy is a mixture of two or more metals, or of a metal and other elements (2, p. 20).

Burning into sand.--Burning into sand is a rough sandy appearance of the outer part of a casting with some sand embedded in the surface (2, p. 22).

<u>Casting</u>.--Metal objects cast to the required shape by pouring or otherwise injecting liquid metal into a mold, as distinct from one shaped by mechanical process, are termed castings (4, p. 79).

<u>Cold shut</u>.--A cold shut is a lack of joining of metal where two streams met leaving an apparent crack or a weakness which may result in a crack (2, p. 20.

<u>Ferrous</u>.--Ferrous refers to alloys in which the predominant metal or solvent is iron (4, p. 74).

<u>Gas holes</u>.--Gas holes are spherical holes under or near the surface of a casting. The insides of these gas cavities are untarnished (2, p. 22).

<u>Ingot</u>.--An ingot is a mass of metal cast in a form convenient for storage or transportation (9, p. 366).

<u>Non-ferrous</u>.--Non-ferrous refers to alloy in which the predominant metal or solvent is not iron (4, p. 74).

<u>Scrap metal</u>.--Scrap metal is discarded metal suitable only for reprocessing (7, p. 665).

<u>Surface stains</u>.--Surface stains are black discolorations of varying sizes and shapes on the surface of castings (2, p. 20).

Tin or lead sweats.--Tin or lead sweats are spots, lumps, or thin layers of white metal on the surface of a casting (2, p. 22).

Wormy surface.--A wormy surface is irregular shallow enlongated depressions in the vicinity of the gate, similar to worm tracks, which are often filled. They are sometimes accompanied with poor fractures (2, p. 20).

Related Studies

Several studies were found that dealt with metalworking facilities and/or metalworking curriculum in Texas high schools, but little material was discovered relating to the foundry area.

Lange, in a 1976 study (6), was concerned with foundry facilities in the industrial arts programs in the state of Texas. In this study it was found that the average percentage of laboratory space provided for foundry was 11 per cent of the total laboratory floor space. Aluminum appears to be the most widely used metal for foundry work in high school industrial arts programs. It appears that while few schools are well equipped for foundry, the majority of the schools have very little in the way of foundry equipment.

An earlier study by Teague, in 1972 (8), sought to determine the physical facilities of the metalworking laboratories in Texas high schools. One of his findings that related directly with this study was 38 per cent of the schools with a foundry area reported inadequate ventilation in this area, and air movement by the cooling system was inadequate in 38 per cent of the laboratories.

Also in 1972, a study by Henley (5) dealt with the metalworking curriculum in Texas high schools. One of his findings was that the state-prescribed curriculum requires a prerequisite of General Metalworking II. However, 2 per cent of the instructors required no prerequisite, 6 per cent required Introductory Metalworking and 6 per cent required "other prerequisites" rather than General Metalworking I.

Sources of Data

Data compiled for this study were obtained from the following sources.

1. An instrument completed by thirty Texas high school industrial arts metalworking instructors including foundry in their curriculum.

2. Unpublished materials such as theses concerned with metalworking.

3. Reference books and periodicals pertaining to the foundry.

4. Information from publications concerning the foundry metals.

Organization of the Study

An introduction, statement of the problem, background and significance of the study, limitations of the study, definition of terms, related studies, sources of data, and organization of the study are presented in Chapter I of this study.

Chapter II includes the development and distribution of the instrument and information regarding the selection and organization of the material required to answer questions posed in Chapter I.

Chapter III presents the data concerning the foundry metals and supplies in the industrial arts programs in the high schools of Texas.

Chapter IV is a summary, conclusions drawn from the findings, and recommendations based upon the findings.

CHAPTER BIBLIOGRAPHY

1. "Alcoa Recyclogram," Time Magazine, 107 (May, 1976), 37.

2. Cowles, F. T., An Elementary Foundry Manual, Danville, Illinois, McEnglevan Heat Treating and Manufacturing Company, 1964.

3. Gerrish, Howard H., "A New Shop Philosophy for Industrial Arts," American Vocational Journal, 41 (January, 1966), 20.

4. Gould, Dudley C., AFS Metalcasting Dictionary, Des Moines, Iowa, Golf and Wolf Rhodes, 1968.

5. Henley, Robert P., "A Study of the Metalworking Curriculum in Texas High Schools, with Special Reference to the Machine Areas of General Metalworking I and II," unpublished master's thesis, Department of Industrial Arts, North Texas State University, Denton, Texas, 1972.

6. Lange, Robert D., "Foundry Facilities in Industrial Arts Programs in the State of Texas," unpublished master's thesis, Department of Industrial Arts, North Texas State University, Denton, Texas, 1976.

7. Ludwig, Oswald A. and Willard J. McCarthy, Metalwork Technology and Practice, Bloomington, Illinois, McKnight and McKnight Publishing Company, 1969.

8. Teague, Ben W., "A Study of the Facilities of Industrial Arts Metalworking Laboratories in the State of Texas," unpublished master's thesis, Department of Industrial Arts, North Texas State University, Denton, Texas, 1972.

9. Woolf, H. B., The Merrian-Webster Dictionary, New York, Pocket Books, 1975.

CHAPTER II

DEVELOPMENT AND DISTRIBUTION OF THE INSTRUMENT

This chapter defines the instrument which was developed and distributed in order to accurately gather the data necessary for this study. The instrument developed (see Appendix B) was entitled "The Source and Treatment of Metal in the Foundry" and was based upon selected questions of related topics and a publication by the McEnglevan Heat Treating and Manufacturing Company entitled An Elementary Foundry Manual (1, pp. 20-23). The instrument consisted of three sections. Section I included general information about foundry metals used in Texas high school foundries. Section II involved information pertaining to the use of new metals, and Section III dealt with the use of scrap metals in school foundries.

General Information

The purpose of Section I was to gather information concerning the types of metals, amounts used, storage, pouring temperatures, sources of foundry metals, and the usage of scrap metals with new materials. The six questions in Section I are explained in the following discussion.

Types of metals used.--There are a variety of metals available for use in the foundry, depending on the needs of the user. Question one was designed to determine the type, or types, of metal which are being utilized in secondary school foundry classes in Texas.

Amount of foundry metal used.--Since each school foundry program is different, the amount of metal used would vary among schools. To gather these data, question two listed types of metals with a blank space provided beside each to show the amount used in pounds. Space was also provided for the indication of whether a semester or trimester system was used.

Storage of foundry metal.--Proper storage of metals is important. Question three sought to determine where metals were stored. Choices given included storerooms, cabinets, and other storage areas.

Temperature for pouring.--One of the most important considerations in good casting is that molten metal be poured at the correct temperature. Question four was structured to determine the temperatures used in pouring various foundry metals.

Supply of foundry metal.--The purpose of this question was to ascertain the availability of foundry metals which are currently being used at the high school level.

New metal mixed with scrap.--Question six was designed to determine to what extent new metal was used with scrap metal in order to upgrade the quality of the casting.

New Metals

A variety of information on new metals was requested in Section II. This section was concerned with the sources, amounts, types, and prices of foundry metals. Nine questions were included in Section II.

Form of metal.--The form that metals come in can make a big difference in the ease of use. Large pieces that need to be cut down can create problems for the instructor. For this reason, question one asked about the form in which metals were received.

Pure or alloy.--There are a variety of grades and alloys that can be used in the foundry. The type of casting can regulate the type of alloy used. Question two asked the instructors to indicate whether pure metals or alloys were used.

Size of metals.--Question three asked the approximate weight of the metals used. Four categories were listed to simplify completion of the question.

Source of metal.--Through the years the foundry has gained much recognition in the industrial field. More and more products are being made by the foundry method. Because of this more people in industry are interested in the educational aspects of the foundry field and often are willing to donate, or sell at a low price, metals for use in instructional endeavors of high schools. Question four sought to determine the sources of metals used in schools.

Metals purchased or donated.--Questions five and six were designed to ascertain the amount of new foundry metals received either by purchase or by donations. These questions were divided into types of metals and weight ranges.

Cost of foundry metals.--The cost of foundry metals influences the amount of metals used in a high school foundry. Questions seven and eight sought to ascertain the cost of metals to the schools and the amounts students were required to pay for metals.

Fluxes.--Question nine listed the different types of fluxes used in foundries. Because a flux suitable for one metal may not be satisfactory for another, a variety of fluxes must be used. Question nine was designed to determine what fluxes were being used.

Scrap Metal

Section III dealt with the use of scrap metals. In the past few years the need for the use of scrap metals has increased considerably because (a) scrap metals are much easier and cheaper to obtain. Scrap metals can be obtained from scrap yards, old lawn mower parts, car parts, and a host of other sources, and (b) scrap metals can be used well for most school castings. Section III consists of nine questions. The questions in this section are somewhat similar to those in Section II.

Source of scrap metal.--Many products today are made of metals that can be recycled. Because of this scrap metals are becoming easier to obtain. Question one was designed to find out the sources of scrap metals.

Amount of scrap metal used.--Questions two and three pertained to the amount of foundry metals purchased and the amounts donated. These questions were also divided according to the types of metals and amount used.

Cost of scrap metal.--Questions four and five were designed to ascertain the cost of the scrap foundry metals to the school and to the student.

Use of scrap metal.--The purpose of question six was to gather information concerning the treatment of the scrap metal upon delivery. This question asked if, when using scrap metal, the respondents melted and used it as is, or melted it and poured it into ingots for later use.

Types of fluxes.--With the use of scrap metals, it is imperative to remove the impurities from the molten metal. No one flux will work for all types of foundry metals, therefore information concerning the kinds of fluxes used was sought.

Problems with scrap metal.--Question eight asked what problems, if any, were encountered when using scrap metals. Possible problems were listed to simplify response to this question.

Suggestions.--Question nine asked the respondent to list any specific suggestions that he might have regarding the use of scrap metals.

Distribution of the Instrument

For the purpose of gathering the most representative data possible, a letter of introduction was included with a copy of the instrument to all high schools in the state of Texas known to have foundry facilities in their metals programs. A list of forty-eight schools located throughout Texas which were used in a related study by Lange (2) was selected to participate. Of the forty-eight instruments which were distributed, one was returned because the instructor had moved. Of the remaining forty-seven instruments, thirty, or 63.8 per cent, were completed and returned by the instructors in time for use in the study.

Six weeks were given to receive the instruments back from responding teachers. No follow up was done to obtain a larger response.

CHAPTER BIBLIOGRAPHY

1. Cowles, F. T., An Elementary Foundry Manual, Danville, Illinois, McEnglevan Heat Treating and Manufacturing Company, 1964.

2. Lange, Robert D., "Foundry Facilities in Industrial Arts Programs in the State of Texas," unpublished master's thesis, Department of Industrial Arts, North Texas State University, Denton, Texas, 1976.

CHAPTER III

PRESENTATION AND ANALYSIS OF DATA CONCERNING FOUNDRY METALS IN THE HIGH SCHOOLS IN TEXAS

Introduction

Contained in Chapter III is a presentation and analysis of the data collected in the study. The three sections of the instrument were: Section I, General Information; Section II, New Metals; and Section III, Scrap Metals. Treatment of the data obtained from Sections II and III was further divided into the various types, sources, cost, storage requirements, and treatment of metals used in the surveyed Texas high schools with foundry as part of their curriculum. Of the forty-eight instruments mailed, thirty responses, or 62.5 per cent of the total, were completed and returned.

Presentation and Analysis of Data

The data obtained from the instrument were treated on a number and percentage basis. Each item in the instrument was calculated for the number and percentage of schools using new and scrap metals and supplies listed.

General Information

Types of metals used.--The data contained in Table I indicate that all instructors surveyed used aluminum as a basic metal. Fifteen, or 50.0 per cent, of the instructors included brass; seven, or 23.3 per cent, used lead; and only one, or 3.3 per cent, used copper. None of the instructors responding reported the use of iron or other metals in their foundry programs.

Many instructors gave more than one answer, this accounts for more than 100.0 per cent responses.

TABLE I

TYPES AND EXTENT OF USE OF METALS IN THE HIGH SCHOOL FOUNDRIES

Types of Metals	Number of Respondents	Per Cent
Aluminum	30	100.0
Brass	15	50.0
Lead	7	23.3
Copper	1	3.3

The amount of metal used.--It was found that four, or 13.3 per cent, of the responding instructors were on the semester school system, and twenty-six, or 86.7 per cent, were on the trimester schedule. Data concerning the amount of metal used for each of these systems were treated separately.

Students in the semester system schools used an average of 181.2 pounds of aluminum per semester. However, amounts used by students ranged from 75 to 250 pounds. Two of the semester system schools reportedly used an average of 100 pounds of brass each semester; and one instructor indicated that his students used twenty-five pounds of lead.

All of the students in the trimester system schools used an average of 147.1 pounds of aluminum per trimester. The range, however, was from three pounds to 1,000 pounds. Fifteen, or 50.0 per cent, of the instructors in the trimester system schools stated that their students used an average of 40.46 pounds of brass.

The range of brass usage was one to 300 pounds. Six instructors in the trimester system, or 23.3 per cent, used an average of 11.8 pounds of lead. The range was five to twenty-five pounds of lead. The only instructor who reported the use of copper was in a trimester school and reported the use of an average of twenty pounds of copper each trimester.

Metal storage.--The data revealed that foundry metals were stored in a variety of places. However, fifteen, or 50.0 per cent, of the instructors stated that the metal was kept in a special storage room. Eight instructors, or 26.6 per cent, indicated that various metals were kept in the foundry area. Four, or 13.4 per cent of the instructors, reported the storage of metals in a special cabinet. One instructor, or 3.3 per cent, placed metals on a balcony, and another instructor, or 3.3 per cent, kept the metals outside the laboratory.

One instructor, or 3.3 per cent, did not respond.

Metal pouring temperature.--A variety of aluminum pouring temperatures was used according to data received. These temperatures varied from 1150 to 1800 degrees Fahrenheit. Figure 1 shows the number of instructors and the various temperatures used in their situation. No data were collected for lead or copper pouring temperatures.

Figure 1 shows that seventeen instructors, or 56.6 per cent, poured aluminum at 1300 to 1500 degrees Fahrenheit. The average aluminum pouring temperature was 1434 degrees Fahrenheit.

Data for brass was more consistent, reporting pouring temperatures ranging from 1750 to 2025 degrees Fahrenheit. The average pouring temperature was 1906 degrees Fahrenheit. As noted in Figure 1, six, or 20.0 per cent, of the instructors did not indicate aluminum pouring temperatures and seven, or 23.3 per cent, of the instructors did not respond for brass usage.

Difficulty in obtaining metal.--Twenty-six, or 86.6 per cent, of the instructors had little or no difficulty in obtaining foundry metal. Three, or 10.0 per cent, stated that they did have difficulty in keeping metal on hand. One, or 3.3 per cent, did not respond to this question.

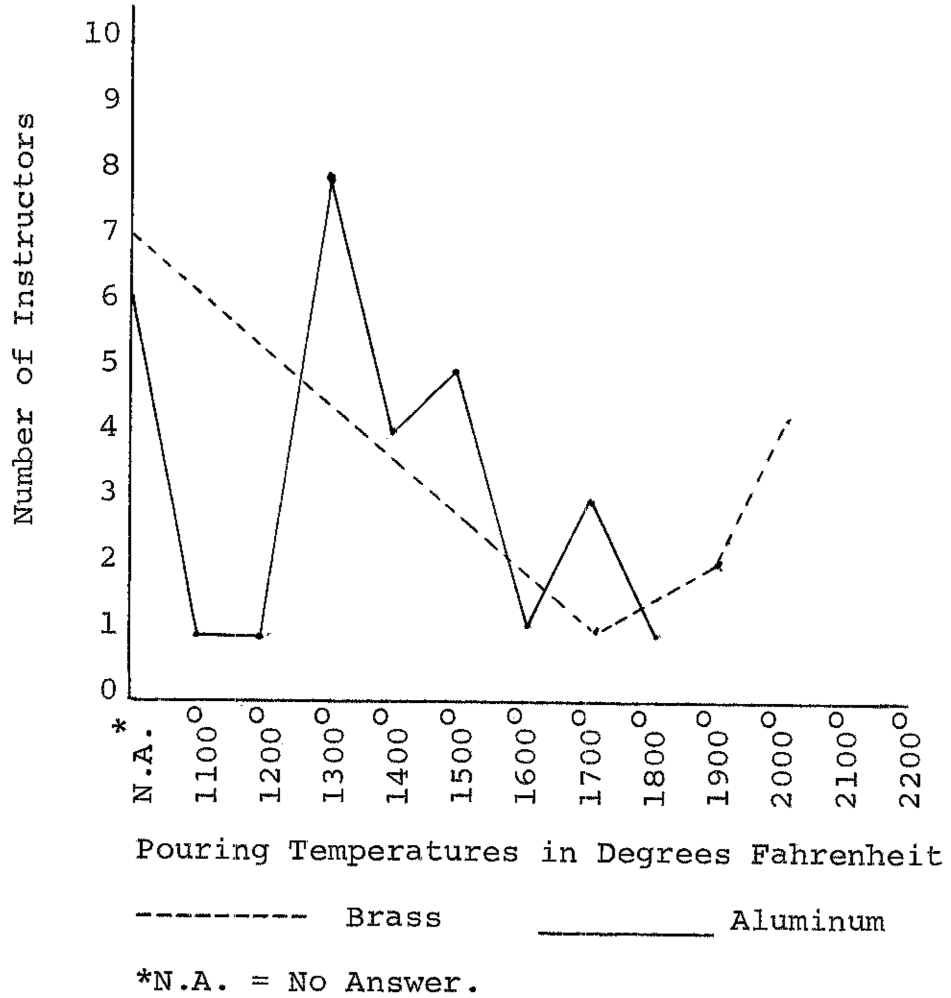

Fig. 1--Metal Pouring Temperatures for Brass and Aluminum

<u>Percentage of new metal used when using scrap</u>.--Data for these responses are presented in Figure 2-A, Figure 2-B, and Figure 2-C. Figure 2-A shows that ten, or 33.3 per cent, used 5 to 20 per cent new metal when using scrap; five, or 16.7 per cent, used 21 to 40 per cent; six, or 20.0 per cent, used 41 to 60 per cent; and one, or 3.3 per cent, used up

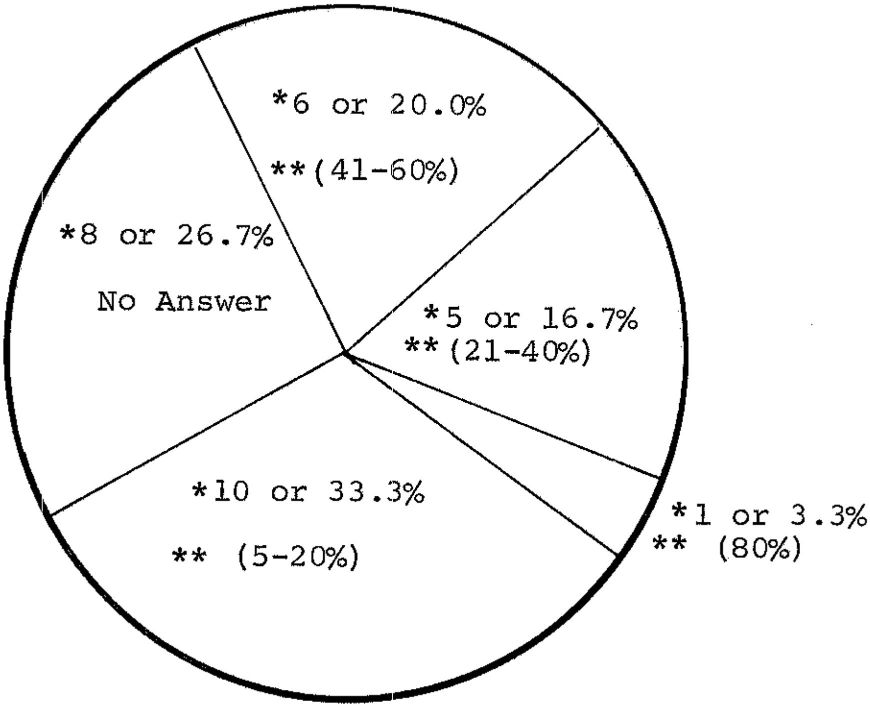

Figure 2-A
Aluminum

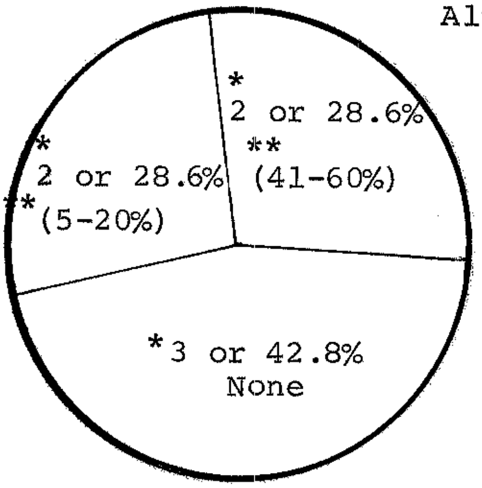

Figure 2-B
Lead

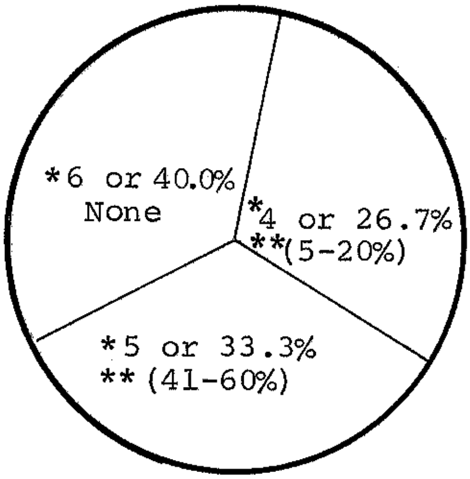

Figure 2-C
Brass

Fig. 2--Percentage of new material used when using scrap as reported by the respondents.

*Instructors **New Materials.

to 80 per cent new metal for each pour. It is interesting to note, however, that eight, or 26.7 per cent, of all instructors responding used straight scrap aluminum when pouring.

Figure 2-B reveals that three instructors, or 42.8 per cent, used no new metals when pouring scrap lead; two, or 28.6 per cent, used from 5 to 20 per cent new metals; and two, or 28.6 per cent, used 40 to 60 per cent new metals.

Figure 2-C shows that six instructors, or 40.0 per cent, used no new brass when pouring scrap brass; four, or 26.7 per cent, used 5 to 20 per cent; and five, or 33.3 per cent, used from 41 to 60 per cent new metals.

No responses were made to this question pertaining to the use of copper.

New Metals

Shapes of new metals.--Data received indicated that eighteen, or 75.0 per cent, of the respondents received new aluminum in ingots, while six, or 25.0 per cent, obtained new metal in other forms; however, shapes were not stated.

Pure or alloy metals.--Shown in Table II are data concerning the use of new pure or alloy metals in the foundry. Nine of the instructors, or 30.0 per cent, indicated the use of pure aluminum. Sixteen instructors, or 53.4 per cent, used an alloy of aluminum, and five, or 16.6 per cent, did not respond to this part of the instrument.

Pure lead was used by three, or 10.0 per cent, of the instructors. Two, or 6.6 per cent, used an alloy of leads, and two, or 6.6 per cent, did not indicate the use of alloys.

TABLE II

TYPES OF METALS, PURE OR ALLOY, USED IN TEXAS HIGH SCHOOL FOUNDRIES

Types of Metals	Number of Responses*	Per Cent of Responses	Pure Metal		Alloy	
			Number of Responses	Per Cent	Number of Responses	Per Cent
Aluminum	25	83.3	9	30.0	16	53.4
Lead	5	16.7	3	10.0	2	6.7
Brass	12	40.0	0	0.0	12	80.0
Copper	1	3.3	0	0.0	1	3.3

*This column does not total 30 due to several instructors responding to more than one type of metal.

Brass was used by twelve instructors, or 40.0 per cent; one instructor, or 6.7 per cent, used pure brass; and three, or 10.0 per cent, did not respond.

Of the thirty teachers, only one instructor indicated the use of copper. Both pure and alloyed copper were used.

New metal sizes.--New metals are obtainable in a variety of sizes. Table III shows that eighteen instructors, or 60.0 per cent, obtained aluminum in one to ten pound ingots; three, or 10.0 per cent, in eleven to twenty pound pieces, seven, or 23.4 per cent, of the respondents received their aluminum in twenty-one to thirty pound ingots; and four, or 13.3 per cent, of the instructors stated that they received ingots weighing over thirty pounds. Four, or 13.3 per cent, did not respond. It is interesting to note that six instructors obtained their aluminum in more than one size ingot. This accounts for the fact that the total responses concerning aluminum sizes numbered thirty-two.

TABLE III

TYPES AND QUANTITIES OF NEW METALS OBTAINED BY INSTRUCTORS

Types of Metals	Size of Metals								Total** Response	
	1-10 lbs.		11-20 lbs.		21-30 lbs.		Over 30 lbs.			
	N.R.*	Per Cent	N.R.	Per Cent	N.R.	Per Cent	N.R.	Per Cent	N.R.	Per Cent
Aluminum	18	60.0	3	10.0	7	23.4	4	13.3	32	106.7
Lead	4	13.3	0	0.0	1	3.3	1	3.3	6	19.9
Brass	10	33.3	0	0.0	1	3.3	1	3.3	12	39.9

*N.R. = Number of Responses.

**Some instructors responded to more than one size range, therefore, some of the percentages total more than 100 per cent.

Lead was obtained in one to ten pound sizes by four, or 13.3 per cent, of the instructors. One instructor, or 3.3 per cent, used twenty-one to thirty pound ingots, and one, or 3.3 per cent, of the instructors used ingots of lead weighing in excess of thirty pounds. None of the responding instructors indicated that lead was available in eleven to twenty pound ingots, while two, or 6.6 per cent, did not respond. One instructor reported that he obtained lead in two different weights.

Brass weights were similar to the lead sizes in that no instructors obtained brass in eleven to twenty pound ingot sizes. Ten instructors, or 33.3 per cent, used one to ten pound ingots; one, or 3.3 per cent, used ingots in the twenty-one to thirty pound range; and one, or 3.3 per cent, used brass ingots above the thirty pound range. Four instructors, or 13.3 per cent, did not respond.

The one instructor who reported the use of copper did not answer this question.

Sources of new metals.--Data collected indicated seven basic sources of new metals. These sources were: gifts from industrial concerns, gifts from individuals, foundries, scrap yards, school warehouses, and lawnmower and automotive repair shops. Twenty-four instructors, or 80.0 per cent, stated that they received their metal as gifts from companies, and eight, or 26.6 per cent, reported gifts from individuals. Fourteen instructors, or 46.6 per cent, stated that scrap yards were a source of metals. Foundries were the source for seven, or 23.3 per cent, of the instructors. Only one instructor, or 3.3 per cent, reported the use of the school system's warehouse as a source of metals. One instructor, or 3.3 per cent, indicated that lawnmower and automotive repair shops were a source of metals.

Ten instructors, or 33.4 per cent, obtained their metals from only one source; sixteen, or 53.3 per cent, had two sources; and four, or 13.3 per cent, obtained metals from more than two places.

Size of purchases in pounds.--Table IV presents the data indicating the quantity of metal purchases made by instructors.

TABLE IV

TYPES AND QUANTITIES OF NEW METALS PURCHASED BY INSTRUCTORS

Types of Metals	Range in Pounds								Total Responses	
	1-50 lbs.		51-100 lbs.		100-150 lbs.		Over 150 lbs.			
	N.R.*	Per Cent	N.R.	Per Cent	N.R.	Per Cent	N.R.	Per Cent	N.R.	Per Cent
Aluminum	2	6.6	4	13.3	5	16.7	2	6.6	13	43.1
Lead	2	6.6	1	3.3	0	0.0	0	0.0	3	9.9
Brass	2	6.6	1	3.3	2	6.6	0	0.0	5	16.5

*N.R. = Number of Responses.

Aluminum purchased varied greatly in amounts, although no data were collected to indicate the reason for this variance. Two instructors, or 6.6 per cent, ordered one to fifty pounds at a time. Four instructors, or 13.4 per cent, indicated the purchase of 51 to 100 pounds each time a purchase was made. Five, or 16.7 per cent, indicated the purchase of 101 to 150 pounds per time. Two instructors, or 6.7 per cent, bought 800 to 1,000 pounds each time they purchased aluminum. Seventeen instructors, or 56.7 per cent, did not report the number of pounds of aluminum purchased at a time.

Lead purchases tended to be smaller than those for aluminum. Two instructors, or 6.6 per cent, bought less than fifty pounds per order, and one instructor, or 3.3 per cent, purchased fifty to 100 pounds per order. Twenty-four instructors, or 90.0 per cent, did not indicate the amount ordered at any given time.

Although brass was used by fifteen, or 50.0 per cent, of the instructors, their orders also were small. Two, or 6.6 per cent, of the respondents indicated that they purchased less than fifty pounds at a time. One instructor, or 3.3 per cent, bought fifty to 100 pounds per order, and two, or 6.6 per cent, purchased 100 to 150 pounds at each purchase. There was no response by the instructors to this question.

Table V presents data concerning donations of metals to instructors responding to the questionnaire. Seventeen, or 56.7 per cent, of the thirty instructors received aluminum through donation. Amounts of gifts ranged from less than fifty pounds to 600 pounds per year. Three instructors, or 10.0 per cent, received from one to fifty pounds; eight, or 26.6 per cent, received fifty-one to 100 pounds; and one, or 3.3 per cent, was given 101 to 150 pounds of aluminum. Two respondents, or 6.6 per cent, were given 500 pounds, and one instructor, or 3.3 per cent, received 600 pounds of metals. Two additional instructors, or 6.6 per cent, stated that they were provided all the aluminum they could use. Thirteen, or 43.4 per cent, of the instructors did not answer this item.

TABLE V

TYPES AND QUANTITIES OF NEW METALS DONATED TO THE INSTRUCTORS

Types of Metals	Range in Pounds								Total Responses	
	1-50 lbs.		51-100 lbs.		101-150 lbs.		Over 150 lbs.			
	N.R.*	Per Cent	N.R.	Per Cent	N.R.	Per Cent	N.R.	Per Cent	N.R.	Per Cent
Aluminum	3	10.0	8	26.6	1	3.3	5	16.7	17	56.6
Lead	2	6.6	0	0.0	0	0.0	0	0.0	2	6.6
Brass	5	16.6	4	13.3	1	3.3	0	0.0	10	33.3

*N.R. = Number of Responses.

Only two instructors, or 6.6 per cent, of the seven instructors using lead received donations of this metal. The other five, or 16.6 per cent, gave no indication of donations of lead.

Brass donations were made to ten, or 33.3 per cent, of the fifteen instructors using brass. Five, or 16.6 per cent, received from one to fifty pounds; four, or 13.3 per cent, received fifty-one to 100 pounds; and one, or 3.3 per cent, received a donation of 100 to 150 pounds of brass. Five instructors, or 16.6 per cent, who use brass did not answer.

No donations of copper were reported in the data received.

Metal cost per pound to schools.--A study of the data presented in Table VI shows that the average cost per pound for metals used was thirty-nine cents for aluminum, thirty cents for lead, seventy-one cents for brass, and copper was obtained without cost.

Of the thirty instructors, thirteen, or 43.3 per cent, stated that they did not have to pay for their aluminum. Eight, or 26.7 per cent, of the instructors paid up to thirty-five cents per pound; three respondents, or 10.0 per cent, stated that they paid thirty-six to seventy-five cents per pound; and two instructors, or 6.6 per cent, bought aluminum for over seventy-five cents per pound. The actual costs reported by these instructors were $1.00 and $1.25 per pound. Four instructors, or 13.3 per cent, did not respond to the question.

Of the instructors who used lead, four, or 13.3 per cent, reported that lead was obtained at no cost. One instructor, or 3.3 per cent, paid up to thirty-five cents per pound, and one instructor, or 3.3 per cent, paid thirty-five to seventy-five cents per pound. The highest actual cost was fifty cents per pound. One instructor, or 3.3 per cent, did not answer the question.

TABLE VI

TYPES OF METALS AND COST PER POUND TO INSTRUCTORS

Types of Metals	Number of Responses	Per Cent Responses	Average Cost Per Lb.	Cost Range in Cents								Total Response	
				No Cost		1-35¢		36-75¢		Above 75¢			
				N.R.*	Per Cent	N.R.	Per Cent	N.R.	Per Cent	N.R.	Per Cent	N.R.	Per Cent
Aluminum	30	100.0	$.39	13	43.3	8	26.7	3	10.0	2	6.7	26	93.3
Lead	7	23.3	.30	4	13.3	1	3.3	1	3.3	0	0.0	6	20.0
Brass	15	50.0	.71	8	26.6	1	3.3	2	6.6	1	3.3	12	40.0

*N.R. = Number of Respondents.

Eight, or 26.6 per cent, of the instructors using brass reported no cost for the brass used. One instructor, or 3.3 per cent, indicated that brass cost up to thirty-five cents per pound. Two respondents, or 6.6 per cent, reported payment of thirty-six to seventy-five cents per pound, and one instructor, or 3.3 per cent, paid over seventy-five cents per pound. Three instructors, or 10.0 per cent, did not respond.

One instructor, or 3.3 per cent, who used copper stated that he received copper at no cost.

Metal costs per pound to student.--Data concerning the various charges to students for metals are presented in Table VII. Two instructors, or 6.6 per cent, did not charge the students for aluminum used in the laboratory for instructional purposes. Fourteen respondents, or 46.7 per cent, indicated a charge of up to seventy-five cents per pound for aluminum projects, and four, or 13.3 per cent, charged from seventy-six cents to $1.45 per pound for aluminum. The highest price any students were charged for aluminum projects was $1.45 per pound. Ten instructors, or 33.3 per cent, did not respond to the question.

None of the instructors offered lead free to the students. Four instructors, or 13.3 per cent of those using lead, charged between seventy-six cents and $1.50 per pound, and one respondent, or 3.3 per cent, charged students $2.85 per pound.

TABLE VII

TYPES OF METALS AND COST PER POUND TO STUDENTS

Types of Metals	Number of Responses	Per Cent of Responses	Average Cost ($)	Cost Range								Total Response	
				No Cost		.01-.75		.76-1.00		Over 1.01			
			Per Lb.	N.R.*	Per Cent	N.R.	Per Cent	N.R.	Per Cent	N.R.	Per Cent	N.R.	Per Cent
Aluminum	30	100.0	$.60	2	6.6	14	46.7	4	13.3	0	0.0	20	66.6
Lead	7	23.3	1.01	0	0.0	4	13.3	0	0.0	1	3.3	5	16.6
Brass	15	50.0	1.19	1	3.3	3	10.0	4	13.3	2	6.6	10	33.2

*N.R. = Number of Respondents.

Two instructors, or 6.6 per cent, did not respond. The average cost to the student was $1.01 per pound.

One instructor, or 6.6 per cent, using brass offered it free to students. Three instructors, or 10.0 per cent, charged up to seventy-five cents per pound; four instructors, or 13.3 per cent, charged seventy-six cents to $1.50 per pound, and two respondents, or 6.6 per cent, charged over $1.50 per pound. The highest rate charged for brass was $2.85 per pound. Five instructors, or 16.6 per cent, did not indicate their charge for brass.

The only instructor using copper charged students ninety cents per pound, even though it was donated at no cost.

Comparison of Table VI and Table VII indicates that, although thirteen instructors received aluminum free, only two passed this benefit on to the students. Excluding the instructors who obtained their aluminum free, the average cost per pound was thirty-nine cents for aluminum. However, the average selling price to the student was sixty cents per pound, or an increase in cost of 54 per cent.

Four instructors, or 13.3 per cent, of those using lead received it free of charge. None of the instructors passed this advantage on to the students. The average cost to the instructors for lead was thirty cents per pound, and it was sold to the students on an average of $1.01 per pound, which is an average of 237 per cent increase.

Eight, or 26.6 per cent, of the instructors received free brass. However, only one, or 3.3 per cent, indicated that no charge was made for brass to students. The average cost to instructors who purchased brass was seventy-one cents per pound, however, it was sold to students for an average of $1.19 per pound. The highest price charged per pound to the students was $2.85. On the average, 68 per cent increase was made on brass.

Only one instructor reported the use of copper. Although the copper was donated, a price of ninety cents per pound was charged students for copper used in projects in the laboratory for educational instruction.

Fluxes used for new metals.--Data in Figure 3 indicate that fifteen, or 50.0 per cent, of the instructors used a degasser when pouring hot metals. Ten instructors, or 33.3 per cent, used coverall flux. Deoxidizer, Slax Flux, and Cuprit were used by three, or 10.0 per cent, of the instructors. Cuperex was used by one instructor. One instructor did not know what was used, and seven, or 23.3 per cent, used no flux when casting new metals. Other fluxes such as Nucleant, Terrp-paint, and Inotab were not used by any of the instructors.

Scrap Metals

The data presented thus far were concerned with new metals obtained for use in high school foundry programs.

The data concerning the use of scrap metals used in foundry laboratories are discussed in the following paragraphs.

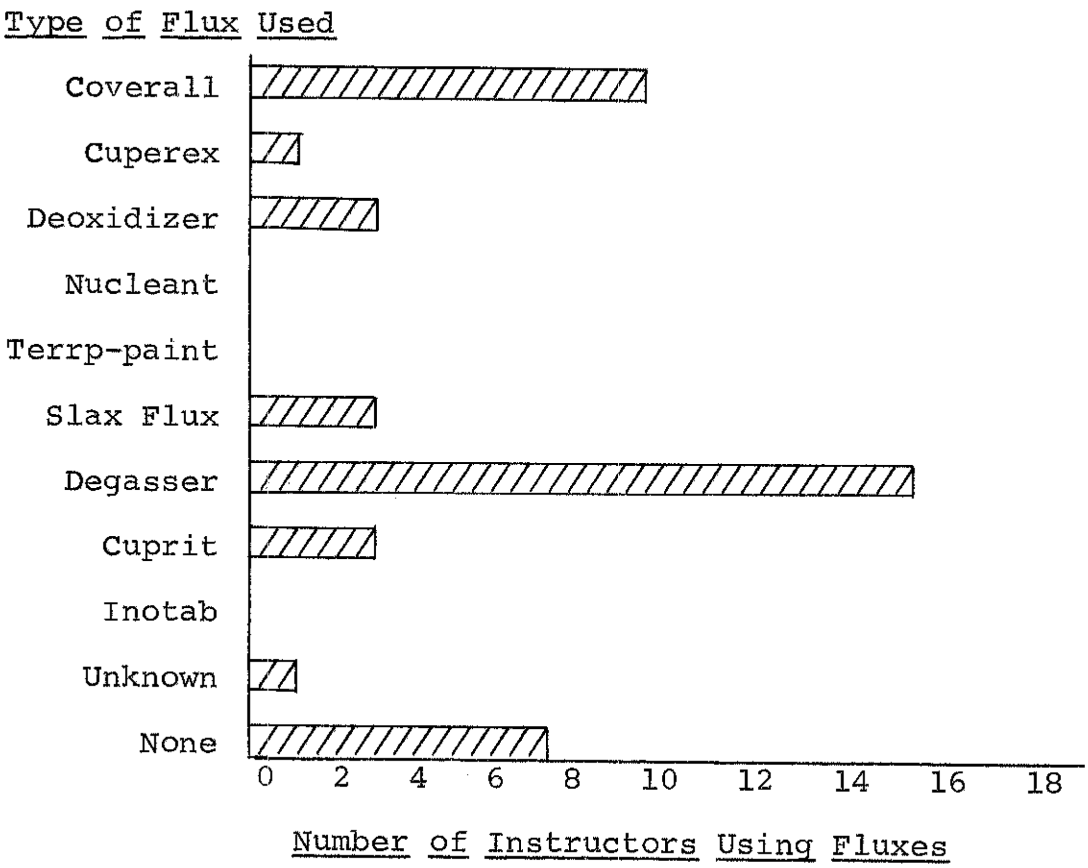

Fig. 3--Number of instructors and types of fluxes used with new metals.

Sources of scrap metals.--Although places where scrap metals may be obtained are many, for the purpose of this study, four general sources were used. These included scrap yards, industrial concerns, students, and others.

Interpretation of the data revealed that sixteen, or 53.3 per cent, of the instructors bought metal from scrap yards; six, or 20.0 per cent, bought metals from industrial concerns; and fifteen, or 50.0 per cent, received donations of scrap metals from industrial concerns. Students brought in scrap metals for use in six, or 20.0 per cent, of the schools. One, or 3.3 per cent, indicated no use of scrap metals in the foundry program.

Size of scrap purchases in pounds.--The data presented in Table VIII show the range in pounds of scrap metals purchased by the instructors surveyed.

Eleven instructors, or 36.7 per cent, did not purchase scrap aluminum. Two respondents, or 6.6 per cent, indicated the purchase of from one to fifty pounds of scrap per year. Six instructors, or 20.0 per cent, bought from fifty-one to 100 pounds at a time. Three instructors, or 10.0 per cent, purchased over 150 pounds of scrap aluminum each time they ordered. Four instructors, or 13.3 per cent, did not reply.

One instructor using lead, or 3.3 per cent, reported no use of scrap lead. Two respondents using lead, or 6.6 per cent, purchased from 51 to 100 pounds of lead per order, and four, or 13.3 per cent of the instructors using lead did not answer the question.

Six respondents, or 20.0 per cent, did not buy used or scrap brass. Three instructors, or 10.0 per cent, bought from 101 to 150 pounds of scrap at a time. Six, or 20.0 per cent, of the instructors did not respond.

TABLE VIII

TYPES AND QUANTITIES OF SCRAP METALS PURCHASED BY INSTRUCTORS

Types of Metals	Range in Pounds										Total Responses	
	None		1-50		51-100		101-150		Over 150			
	N.R.*	Per Cent	N.R.	Per Cent	N.R.	Per Cent	N.R.	Per Cent	N.R.	Per Cent	N.R.	Per Cent
Aluminum	11	36.7	2	6.7	6	20.0	4	13.3	3	10.0	26	86.6
Lead	1	3.3	0	0.0	2	6.6	0	0.0	0	0.0	3	10.0
Brass	6	20.0	0	0.0	0	0.0	3	10.0	0	0.0	9	30.0

*N.R. = Number of Respondents.

The only instructor using copper did not use scrap copper in the foundry.

Size of scrap metals donations.--Data in Table IX shows that gifts of aluminum scrap varied among schools. The range in pounds was zero to over 1,000 pounds. Five, or 16.7 per cent, of the instructors did not receive any aluminum scrap as donations, yet six respondents, or 20.0 per cent, obtained gifts of over 150 pounds. One instructor received 1,000 pounds each year. Two respondents, or 6.6 per cent, indicated gifts of metals were over 500 pounds per year. Two instructors, or 6.7 per cent, received from one to fifty pounds of aluminum scrap; ten, or 33.3 per cent, received fifty-one to 100 pounds; and two instructors, or 6.6 per cent, were given 101 to 150 pounds of scrap aluminum each year. Five, or 16.7 per cent, of the instructors did not reply to this question.

Donations of scrap lead were smaller than those for scrap aluminum. Three instructors, or 10.0 per cent, of the respondents were given one to fifty pounds, and two respondents, or 6.6 per cent, received no scrap lead. Two instructors, or 6.6 per cent, did not respond to this item.

Gifts of brass scrap also were smaller than those for aluminum scrap. Five instructors, or 16.6 per cent, were given one to fifty pounds; one respondent, or 3.3 per cent, received 101 to 150 pounds; and two instructors, or 6.6 per

TABLE IX

TYPES AND QUANTITIES OF SCRAP METALS DONATED TO THE INSTRUCTORS

Types of Metals	Range in Pounds										Total Response	
	None		1-50		51-100		101-150		Over 150			
	N.R.*	Per Cent	N.R.	Per Cent	N.R.	Per Cent	N.R.	Per Cent	N.R.	Per Cent	N.R.	Per Cent
Aluminum	5	16.7	2	2.6	10	33.3	2	6.7	6	20.0	25	83.3
Lead	2	6.6	3	10.0	0	0.0	0	0.0	0	0.0	5	16.7
Brass	1	3.3	5	16.7	0	0.0	1	3.3	2	6.6	9	30.0

*N.R. = Number of Respondents.

cent, indicated over 150 pounds were received. One respondent, or 3.3 per cent, did not receive any brass scrap donations, and six, 20.0 per cent, of the instructors did not respond to the question.

No scrap copper donations were reported by any of the instructors.

Scrap metals cost per pound to schools.--The data tabulated in Table X present a comparison of the scrap metals costs per pound to schools. Ten instructors, or 33.3 per cent, did not have to pay for their aluminum scrap. Six, or 20.0 per cent, paid from one to twenty-five cents per pound, and six additional instructors, or 20.0 per cent, paid from twenty-six to fifty cents per pound. No instructors answering the questionnaire paid in excess of fifty cents per pound. Eight respondents, or 26.7 per cent, did not answer this question. The average cost per pound for scrap aluminum was thirty cents.

The price of scrap lead paid by two instructors, or 6.6 per cent, was between twenty-six and fifty cents per pound. Three instructors, or 10.0 per cent, did not pay for scrap lead. Two instructors, or 6.6 per cent, did not report what price was paid for scrap lead. The average cost for scrap lead was fifty cents per pound.

Seven schools, or 23.3 per cent, did not pay for their scrap brass. Three, or 10.0 per cent, of the respondents

TABLE X

TYPES OF SCRAP METALS AND COST PER POUND TO INSTRUCTORS

Types of Metals	Number of Responses	Per Cent Responses	Average Cost ($) Per Lb.	Cost Range								Total Responses	
				No Cost		.01-.25		.26-.50		Over .50			
				N.R.*	Per Cent	N.R.	Per Cent	N.R.	Per Cent	N.R.	Per Cent	N.R.	Per Cent
Aluminum	30	100.0	30	10	33.3	6	20.0	6	20.0	0	0.0	22	73.3
Lead	7	23.3	50	3	10.0	0	0.0	2	6.6	0	0.0	5	16.6
Brass	15	50.0	38	7	23.3	0	0.0	3	10.0	0	0.0	10	33.3

*N.R. = Number of Respondents.

paid from twenty-six to fifty cents per pound, and five instructors, or 16.6 per cent, did not answer this question. The average cost of brass was thirty-eight cents per pound to the schools.

Table X indicates that no instructors using copper paid for scrap copper.

Scrap metals cost per pound to students.--The cost of scrap metals per pound to the student is depicted in Table XI. Only three, or 10.0 per cent, of the respondents indicated no charge to students for scrap aluminum. Three additional instructors, or 10.0 per cent, charged students from one to twenty-five cents per pound. Twelve instructors, or 40.0 per cent, required students to pay twenty-six to fifty cents per pound, and two respondents, or 6.6 per cent, charged over fifty cents per pound for scrap aluminum. Ten instructors, or 33.3 per cent, did not respond to this item. The average cost to the student for scrap aluminum was fifty cents per pound.

Three instructors, or 10.0 per cent, who responded to using lead charged twenty-six to fifty cents per pound for scrap lead. One instructor, or 3.3 per cent, charged students in excess of fifty cents per pound, and three instructors, or 10.0 per cent, did not indicate what they charged students for scrap lead. The average charge for scrap lead was $1.19 per pound.

TABLE XI

TYPES OF SCRAP METALS AND COST PER POUND TO STUDENTS

Types of Metals	Number of Responses	Per Cent of Responses	Average Cost ($)	Cost Range								Total Response	
				No Cost		.01-.25		.26-.50		Over .50			
			Per Lb.	N.R.*	Per Cent	N.R.	Per Cent	N.R.	Per Cent	N.R.	Per Cent	N.R.	Per Cent
Aluminum	30	100.0	$ .50	3	10.0	3	10.0	12	40.0	2	6.6	20	66.6
Lead	7	23.3	1.19	0	0.0	0	0.0	3	10.0	1	3.3	4	13.3
Brass	5	50.0	1.13	2	6.6	1	3.3	1	3.3	6	20.0	10	33.3

*N.R. = Number of Respondents.

Of the fifteen instructors using brass, two, or 6.6 per cent, made no student charges for scrap brass. One instructor, or 3.3 per cent, charged students from one to twenty-five cents per pound, and another instructor, or 3.3 per cent, charged the pupils twenty-six to fifty cents per pound. Six respondents, or 20.0 per cent, charged students over fifty cents per pound. Five instructors, or 16.6 per cent, did not respond. The average charge per pound for scrap brass was $1.13.

There was no response on student charges for scrap copper.

Refinement of scrap metals.--Three instructors, or 10.0 per cent, indicated a preference of pouring and making projects the first time the scrap metal was melted. Thirteen, or 43.3 per cent, preferred to melt and pour molten metal into ingots for later use. Another thirteen instructors, or 43.4 per cent, used both methods in the laboratory. One instructor did not answer the question.

Fluxes used with scrap metal.--Figure 4 graphically shows the data collected for this item. From the graph it can be seen that sixteen, or 53.3 per cent, of the instructors used Degasser when pouring hot scrap metals. Another twelve respondents, or 40.0 per cent, used Coverall, and three instructors, or 10.0 per cent, used Deoxidizer. Five respondents, or 16.6 per cent, indicated the use of Slax Flux, and

Cuperex and Cuprit were both used by one, or 3.3 per cent, of the instructors. There was no indication that Nucleant, Terrp-paint, or Inotab were used by any of the instructors surveyed. Nine instructors indicated no use of flux when pouring scrap metals.

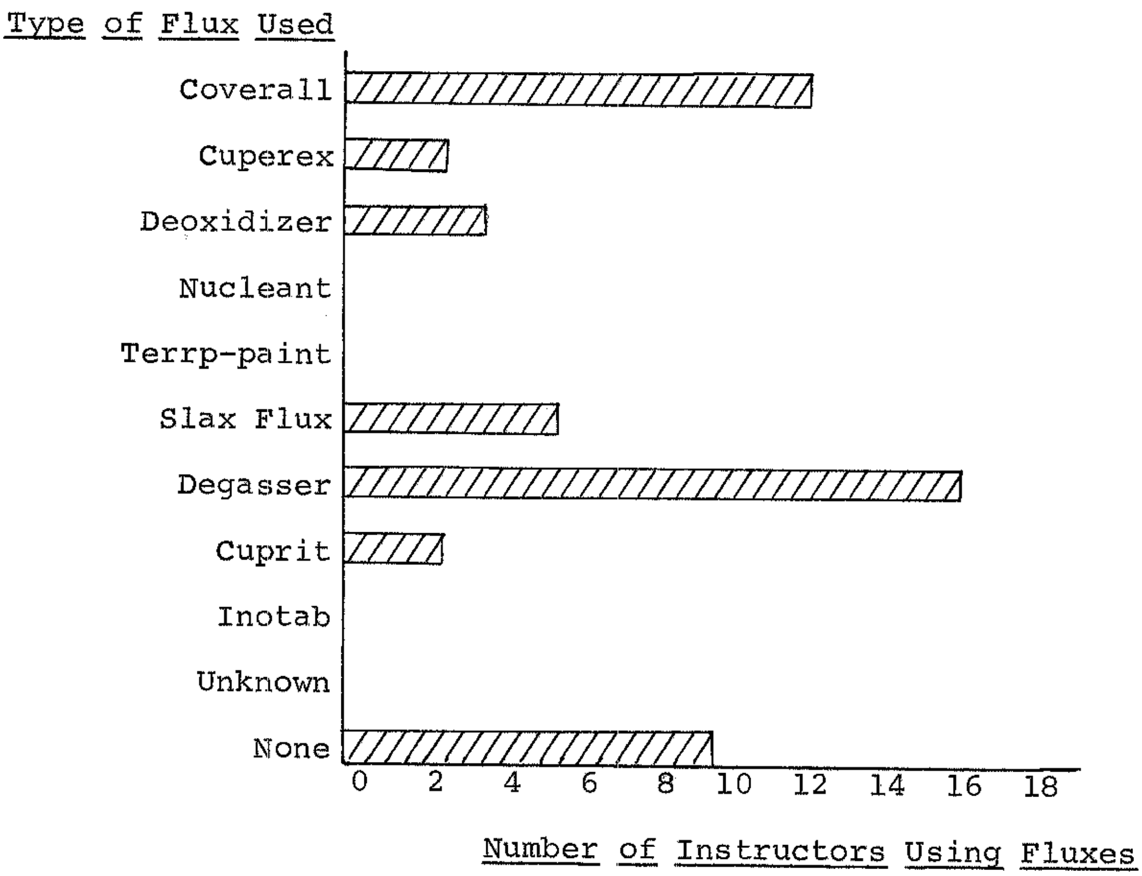

Fig. 4--Number of instructors and types of fluxes used with scrap metals.

Casting problems.--Figure 5 shows the data concerning problems encountered when casting various types of molten metals. For simplicity of response, five types of problems were listed. Respondents were to indicate whether or not

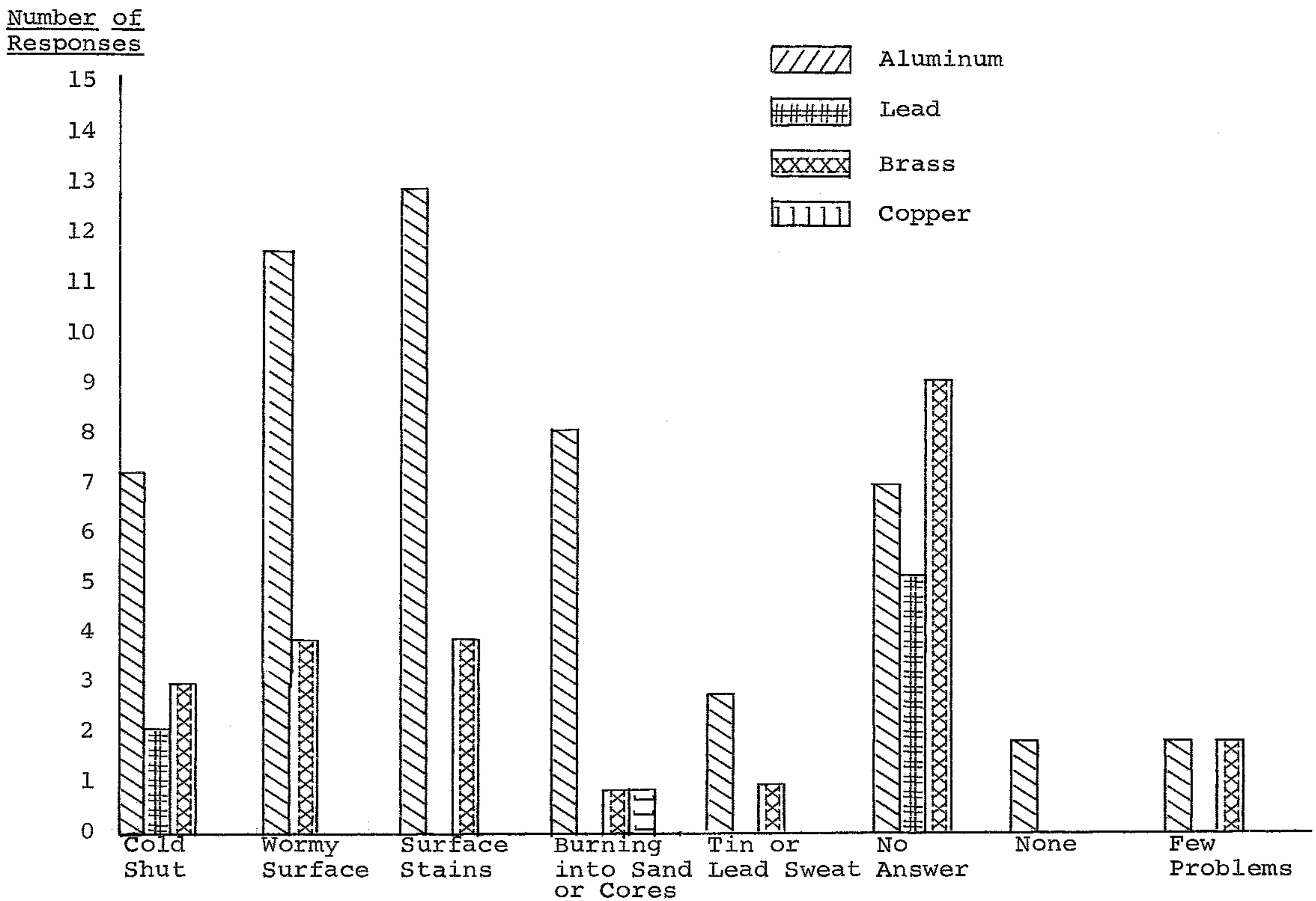

Fig. 5--Casting Problems of Foundry Metals as Reported by Respondents

they experienced any of these difficulties when pouring aluminum, lead, brass, or copper.

Cold shut was experienced by seven instructors, or 23.3 per cent, when pouring aluminum; two, or 6.6 per cent, when pouring lead; and three, or 10.0 per cent, when pouring scrap brass.

Twelve, or 40.0 per cent, of the instructors using aluminum reported having wormy surfaces when pouring aluminum. Four, or 13.3 per cent, also had wormy surfaces when pouring brass.

Burning into sand or cores was experienced by eight, or 26.6 per cent, when casting aluminum, and one, or 6.6 per cent, during a brass pour. The only instructor casting copper also experienced this difficulty.

Tin or lead sweat development was reported by three, or 10.0 per cent, of the instructors when casting aluminum, and by only one, or 6.6 per cent, pouring brass.

No answer was given by seven, or 23.3 per cent, of the respondents pouring aluminum; five, or 16.6 per cent, casting lead; and nine, or 30.0 per cent, pouring brass.

Two instructors, or 6.6 per cent, indicated no problems. Two instructors, or 6.6 per cent, did indicate some problems when pouring aluminum, and another two, or 6.6 per cent, of the respondents indicated some difficulty when pouring brass. None of these instructors, however, described their difficulties.

Helpful suggestions.--The last question on the instrument asked for helpful suggestions in using scrap metals. Only four, or 13.3 per cent, of the respondents offered comments. These suggestions are listed below.

1. When melting aluminum cans, first have some molten metal in the bottom of the crucible.
2. For smoother surfaces, add a small amount of copper to each crucible of aluminum.
3. Make gates and passages large enough for the metal to flow through easily.
4. Melt metal only as often as required to avoid oxidation and waste.

CHAPTER IV

SUMMARY, FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purpose of this study was to determine the types of metals and fluxes used in Texas high school foundries. An additional purpose was to determine how metals were purchased and stored, the amounts used, types of alloys, and cost to instructors and to students.

In order to gather the necessary data, an instrument was developed. An introductory letter and the instrument were mailed to all industrial arts metalworking instructors in the state of Texas known to include foundry as a part of their curriculum. Forty-eight instruments were distributed and thirty usable instruments were returned. Data collected from these instruments were analyzed and presented, utilizing both graphical and tabular forms of presentation.

Findings

Based on the analysis of data presented in this study, the following findings are those considered of greatest importance.

1. Of the instructors providing data for this study, all included aluminum as a basic metal in their foundry

program, one-half included brass, approximately one-fourth included lead, and only one included copper. Iron and other metals were not listed by any of the instructors participating in the study.

2. Instructors used an average of 150 pounds of aluminum, fifty pounds of brass, twelve pounds of lead, and twenty pounds of copper each trimester.

3. Approximately one-half of the instructors stored foundry metals in special storage rooms, one-fourth kept metals in the foundry area, approximately one-eighth kept metals in special storage cabinets, one stored metals on a balcony, and one kept metals outside the foundry area.

4. The average pouring temperature for aluminum was 1,434 degrees Fahrenheit. Brass was poured at an average temperature of 1,906 degrees Fahrenheit. No melting temperatures were given for lead or copper.

5. All of the instructors reported little or no difficulty in obtaining foundry metal, but there was indication that it was difficult to keep on hand.

6. Twenty-two instructors added new aluminum when melting scrap aluminum. Eight respondents used scrap aluminum all together. Four instructors added new lead to the scrap lead pours, and three respondents used only scrap lead. Nine instructors added new brass to scrap brass, but six used scrap brass alone. No data were available for copper.

7. Seventy-five per cent of the instructors who responded indicated that they received new aluminum in ingots weighing approximately fifteen pounds each, brass averaged ten pounds, and lead averaged eight pounds.

8. Nine respondents indicated the use of pure aluminum, and sixteen schools used aluminum alloys. Three instructors used pure lead, and two used alloys. Twelve instructors used brass alloys, and only one used pure brass. The only instructor who used copper as a foundry metal used both pure and alloy copper.

9. Eighty per cent of the instructors indicated the main source of new metals was through gifts from industrial concerns. Approximately 25 per cent received foundry metals as a gift from individuals. Almost 50 per cent utilized new metals from scrap yards, another 25 per cent indicated foundries were a source of supply, and one instructor used the school system's warehouse as a source of supply. Ten instructors obtained new metal from only one source, sixteen from two sources, and four indicated using more than two supply outlets.

10. The average cost per pound for new aluminum when purchased by the instructors was thirty-nine cents per pound, new brass cost seventy-one cents per pound, and new copper was obtained free by the only instructor reporting the use of copper in the foundry program. However, there was a notable difference in buying and selling price. Aluminum was

sold to students at an average cost of sixty cents per pound, lead for $1.01 per pound, brass for $1.19 per pound, and copper for ninety cents per pound.

11. Approximately 50 per cent of the instructors obtained scrap metals from scrap yards; 50 per cent received donations from industrial concerns; 20 per cent purchased scrap metals from manufacturers; and 20 per cent used scrap metal brought in by students. Several instructors received scrap metals from more than one source.

12. The average prices paid by instructors for scrap metals were thirty cents per pound for aluminum, fifty cents per pound for lead, and thirty-eight cents per pound for brass. All copper used was free. As to the resale of scrap metals, students were charged an average of fifty cents per pound for aluminum, $1.19 per pound for lead, $1.13 per pound for brass, and $1.00 per pound for copper.

13. The most frequent problem experienced by instructors when pouring aluminum was surface stains. Thirteen of the instructors reported this problem. Burning into sand and cores was the next most common problem as was reflected by nine respondents. Seven instructors had difficulty with cold shuts-freeze-outs, and three experienced wormy surfaces, or tin or lead sweat. The only significant problems experienced in pouring brass were in cold shuts or surface stains. Three and four instructors, respectively, had these

difficulties. There were no significant difficulties reported in pouring lead or copper.

14. From the data it was found that instructors preferred to use a degasser flux with both new and scrap metals. The instructors also used a coverall flux. Only a few of those reporting used the other fluxes listed.

Conclusions

The following conclusions were drawn from the findings of this study concerning metals and their treatment as used in high school foundries in the state of Texas.

1. Since the most commonly used metal in the high school foundry programs was aluminum, it apparently is an easy metal to handle and lends itself well to high school foundry work.

2. It appears that many industrial concerns have an avid interest in education of the foundry process.

3. It appears that many instructors were not well educated on correct pouring temperatures of the foundry metals.

4. There appear to be few instructors with adequate knowledge in the proper use of fluxes.

5. A sizeable mark-up exists in metals which are sold to students when compared with prices paid by instructors. The savings derived from lower prices due to donations and use of scrap metals do not appear to benefit the students as much as might be expected.

Recommendations

The following recommendations are made on the basis of the findings of this study.

1. A greater variety of pouring experiences be included in the foundry programs.

2. Greater consideration be given to the use of fluxes.

3. Instructors consider passing on to their students some of the benefits of free metals given them.

4. More schools include foundry in their existing industrial arts curriculums.

5. Special emphasis be placed on proper pouring temperatures.

APPENDIX A

April 11, 1976

Industrial Arts Metal Instructor

Dear Sir:

I am currently involved in a graduate study at North Texas State University for the fulfillment of a Master of Science degree in Industrial Arts. The study concerns the source and treatment of metals used in the foundry.

I would appreciate your assistance in providing me with some information by completing the enclosed checklist and returning it at your earliest convenience.

The information will be used in a professional and confidential manner. Be assured that you and your school will remain anonymous.

Thank you for your time and cooperation in helping me with the requested information.

If you wish a copy of the summary of this study, please check the space provided in the checklist. A return envelope is enclosed for your convenience.

Sincerely,

Jerry Underhill
Graduate Student

Enclosure: Instrument

Sponsored by:
Dr. Jerry C. McCain
Professor of Industrial Arts
North Texas State University

APPENDIX B

INSTRUMENT

The Source and Treatment of
Metals in the Foundry

Instructions: Listed below are some questions and practices used in the foundry. Please indicate the answer which is appropriate by placing a check mark ( ) or fill in the blank.

Section I--General Information

1. What types of metals do you use in the school foundry?
aluminum ( ), lead ( ), brass ( )
copper ( ), iron ( ), other ____________.

2. How many pounds of foundry metal do your students use per semester? _____ or trimester? _____
aluminum ___lbs. lead ___lbs. brass ___lbs.
copper ___lbs. iron ___lbs. other _____ __ lbs.

3. Where do you store the foundry metal?
store room ( ), cabinet ( ), other ____________.

4. To what temperature do you heat the metal for pouring?
aluminum ________ lead ________ brass ________
copper ________ iron ________ other _____ _____.

5. Is it difficult to keep a supply of foundry metal on hand? yes ( ), no ( ).

6. When using gates, risers, old projects, shavings, and scraps, what per cent new metal is used?
aluminum 5-20% ( )--21-40% ( )--41-60% ( )
lead 5-20% ( )--21-40% ( )--41-60% ( )
brass 5-20% ( )--21-40% ( )--41-60% ( )
copper 5-20% ( )--21-40% ( )--41-60% ( )
iron 5-20% ( )--21-40% ( )--41-60% ( )
other _____5-20% ( )--21-40% ( )--41-60% ( )

Section II--New Metals

1. In what form does the metal come? (please check)
ingots ( ), other ______________.

2. Is the metal pure or an alloy?
aluminum pure ( )--alloy ( ).
lead pure ( )--alloy ( ).
brass pure ( )--alloy ( ).
copper pure ( )--alloy ( ).
iron pure ( )--alloy ( ).
other ________ pure ( )--alloy ( ).

3. What size does the metal come in?
aluminum 1-10 ( )--11-20 ( )--21-30 ( )--over 30 ( ) lbs.
lead 1-10 ( )--11-20 ( )--21-30 ( )--over 30 ( ) lbs.
brass 1-10 ( )--11-20 ( )--21-30 ( )--over 30 ( ) lbs.
copper 1-10 ( )--11-20 ( )--21-30 ( )--over 30 ( ) lbs.
iron 1-10 ( )--11-20 ( )--21-30 ( )--over 30 ( ) lbs.
other _____ 1-10 ( )--11-20 ( )--21-30 ( )--over 30 ( ) lbs.

4. Where do you secure your metals? commercial foundry ( ), a metals distributor ( ), a gift from a company ( ), a gift from an individual ( ), scrap yard ( ), other _____
________________________________.

5. How much metal do you buy at a time (pounds)?
aluminum 1-50 ( ) 51-100 ( ) 101-150 ( ) more _______
lead 1-50 ( ) 51-100 ( ) 101-150 ( ) more _______
brass 1-50 ( ) 51-100 ( ) 101-150 ( ) more _______
copper 1-50 ( ) 51-100 ( ) 101-150 ( ) more _______
iron 1-50 ( ) 51-100 ( ) 101-150 ( ) more _______
other _____1-50 ( ) 51-100 ( ) 101-150 ( ) more _______

6. How much metal do you receive as a gift? (pounds)
aluminum 1-50 ( ) 51-100 ( ) 101-150 ( ) more _______
lead 1-50 ( ) 51-100 ( ) 101-150 ( ) more _______
brass 1-50 ( ) 51-100 ( ) 101-150 ( ) more _______
copper 1-50 ( ) 51-100 ( ) 101-150 ( ) more _______
iron 1-50 ( ) 51-100 ( ) 101-150 ( ) more _______
other_____1-50 ( ) 51-100 ( ) 101-150 ( ) more _______

7. How much does the metal cost the school? (per pound)
aluminum $______ lead $______ brass $______
copper $______ iron $______ other ______ $______.

8. What are the students charged for these metals? (per pound)
aluminum $______ lead $______ brass $______
copper $______ iron $______ other ________ $______.

9. What types of fluxes do you add to your molten metals?
coverall ( ), nucleant ( ), degasser ( ),
cuperex ( ), terrp-paint( ), cuprit ( ),
deoxidizer ( ), slax flux ( ), inotab ( ),
others List: ______________
____

Section III--Scrap Metals

1. What is the source of scrap metals?
   boutht at a scrap yard ( ), bought from a manufacturer ( ), donated by a company ( ), brought in by students ( ), other ______________________.

2. How many pounds of scrap metals are purchased at a time?

aluminum	1-50 ( ),	51-100 ( ),	101-150 ( ),	more _____
lead	1-50 ( ),	51-100 ( ),	101-150 ( ),	more _____
brass	1-50 ( ),	51-100 ( ),	101-150 ( ),	more _____
copper	1-50 ( ),	51-100 ( ),	101-150 ( ),	more _____
iron	1-50 ( ),	51-100 ( ),	101-150 ( ),	more _____
other _____	1-50 ( ),	51-100 ( ),	101-150 ( ),	more _____

3. How much metal do you receive as a gift? (pounds)

aluminum	1-50 ( ),	51-100 ( ),	101-150 ( ),	more _____
lead	1-50 ( ),	51-100 ( ),	101-150 ( ),	more _____
brass	1-50 ( ),	51-100 ( ),	101-150 ( ),	more _____
copper	1-50 ( ),	51-100 ( ),	101-150 ( ),	more _____
iron	1-50 ( ),	51-100 ( ),	101-150 ( ),	more _____
other_____	1-50 ( ),	51-100 ( ),	101-150 ( ),	more _____

4. How much do you currently pay per pound for scrap metals?
   aluminum $______ lead $_____ brass $_____
   copper $______ iron $_____ other ______$_____

5. What are the students charged for the scrap metals?
   aluminum $_____ lead $_____ brass $_____
   copper $_____ iron $_____ other ______$_____

6. When using scrap metals do you:
   a. melt and use it as is? ( )
   b. melt and pour into ingots for later use? ( )

7. What types of fluxes do you add to your scrap metals?
   coverall ( ), nucleant ( ), degasser ( ),
   duperex ( ), terrp-paint ( ), cuprit ( ),
   deoxidizer ( ), slax flux ( ), inotab ( ),
   others List: ______________
   ____

8. In using scrap metals do you encounter any of the following problems? Please indicate below in provided space.

   Definitions:

   Cold Shut--is a lack of joining of metal where two streams met leaving an apparent crack or weakness which may result in a crack.

Wormy Surface--is irregular shallow elongated depression in the vicinity of the gate, similar to worm tracks, often filled with zinc oxide. Are sometimes accompanied with poor fractures.
Surface Stains--are black discolorations of varying size and shapes on surface of castings.
Burning Into Sand or Cores--is a rough sandy appearance of inner part of casting with some sand embedded in the inner surface or metal find penetrating into core and holding grains of core sand.
Tin or Lead Sweat--is spots, lumps, or a thin layer of white metal on the surface of the casting.

aluminum		lead		brass	
cold shut	___	cold shut	___	cold shut	___
wormy surface	___	wormy surface	___	wormy surface	___
surface stains	___	surface stains	___	surface stains	___
burning into sand or cores	___	burning into sand or cores	___	burning into sand or cores	___
tin or lead sweat	___	tin or lead sweat	___	tin or lead sweat	___

copper		iron		other	
cold shut	___	cold shut	___	cold shut	___
wormy surface	___	wormy surface	___	wormy surface	___
surface stains	___	surface stains	___	surface stains	___
burning into sand or cores	___	burning into sand or cores	___	burning into sand or cores	___
tin or lead sweat	___	tin or lead sweat	___	tin or lead sweat	___

9. Do you have any helpful suggestions in the use of scrap metals? If so please note:
   Type metal_______________ Suggestion _______________
   ____
   ____
   Type metal_______________ Suggestion _______________
   ____
   ____

If you would like a copy of the results of this study, please list your mailing address below. THANK YOU

Name ______________________________
Address ___________________________
City _____________ State ___________
Zip Code ___________

BIBLIOGRAPHY

Books

Ludwig, Oswald A. and Willard J. McCarthy, Metalwork Technology and Practice, Bloomington, Illinois, McKnight and McKnight Publishing Company, 1969.

Woolf, H. B., The Merrian-Webster Dictionary, New York, Pocket Books, 1975.

Articles

"Alcoa Recyclogram," Time Magazine, 107 (May, 1976), 39.

Gerrish, Howard H., "A New Shop Philosophy for Industrial Arts," American Vocational Journal, 41 (January, 1966), 20.

Report

Cowles, F. T., An Elementary Foundry Manual, Danville, Illinois, McEnglevan Heat Treating and Manufacturing Company, 1964.

Publication of Learned Organization

Gould, Dudley C., AFS Metalcasting Dictionary, Des Moines, Iowa, Golf and Wolf Rhodes, 1968.

Unpublished Materials

Henely, Robert P., "A Study of the Metalworking Curriculum in Texas High Schools, with Special Reference to the Machine Areas of General Metalworking I and II," unpublished master's thesis, Department of Industrial Arts, North Texas State University, Denton, Texas, 1972.

Lange, Robert D., "Foundry Facilities In Industrial Arts Programs in the State of Texas," unpublished master's thesis, Department of Industrial Arts, North Texas State University, Denton, Texas, 1976.

Teague, Ben W., "A Study of the Facilities of Industrial Arts Metalworking Laboratories in the State of Texas," unpublished master's thesis, Department of Industrial Arts, North Texas State University, Denton, Texas, 1972.