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Investigation of Art Metal Work

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INVESTIGATION OF

ART METAL WORK

by
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PREFACE

Art metal involves the shaping of non-ferrous metals, such as brass, aluminum, copper, pewter, silver and nickel silver, into decorative and useful articles such as trays, pins, bracelets, and many other accessories for the home.

This paper has been compiled with the intention of providing any person, and especially a teacher contemplating adding art metal instruction in his shop, a general knowledge of the historical background, the metals used, and the equipment and processes involved in art metalcraft.

No effort was made to explain a process to such a degree that it could be used in a course of study or a course syllabus.

I. THE HISTORICAL BACKGROUND OF METAL WORK

Since man first discovered how to use fire, he has constantly been trying to improve his way of life. Metal has made important contributions in this improvement.

> In the lands bordering the eastern limits of the Mediterranean Sea, the early home of the white race, gold and silver had been discovered several thousands of years before the Christian Era, while men were still in a semi-civilized state and were using tools of wheted stone or flint, secured in wooden handles. Yet these primitive people seem instinctively to have appreciated the natural beauty and intrinsic value of these metals, for they fashioned them into gifts for their gods and into ornaments for personal decoration as emblems of wealth and distinction. Other metals had also been discovered-in fact the ancient Greek word metallon, from which "metal" is derived, denoted "something diligently sought." It was not, however, until about 2000 B.C. that these early men learned to make bronze by the fusion of copper and tim, which was brought from distant Wales. This ancient bronze was not only of a peculiarly fine quality but, what is even more important, it was given an additional hardening by a process now unknown, so that it could be made into the sharpest-edged tools.[1]

The following is a list of some of the metals first discovered and some examples of the early craft work in which they were used.

Bronze

The adaptability of bronze for casting, its durability and color, render this material one of extreme beauty and usefulness. Among the examples of antiquity are the 1000 statues of Osiris, found in the temple of Rameses III. In Greece, bronze was wrought with exquisite

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[1] Peter Manzoni, Metalcraft for Amateurs, Boston: The Beacon Press Inc., 1935 p.1.

skill and refinement, and the name of Lysippos (340 B.C.) is associated with the finest statues. Small decorative bronzes consist of candelabra, tripods, tables, chairs and couches, which eighteen centuries ago were used by wealthy Roman citizens.

Gold-Silver

> With their intrinsic value, ductility, and beauty of color, gold and silver have long been associated with the decorative arts of the past, and the many splendid examples still in existence are a tribute to the culture and personality of the craftsmen.[2]

Many early examples were found in 1859 with the mummy of Queen Aah-Hotep (1800 B.C.), and consisted of bracelets, armlets, rings, chains, a diadem, a small model of a war galley, and a poniard, all of exquisite workmanship and of pure gold, enriched with jasper and turquoise. At Petrossa some splendid gold objects of Byzantine workmanship were found consisting of two neck-rings, a large salver, hammered and chased, a ewer, and two double handled cups.

The most important silverwork consists of thirty cups, vases, and dishes, beautiful in contour and admirably enriched with delicate repousse work of the Greco-Roman period.

Iron

The decorative qualities of iron, with its strength and durability, have rendered it one of the most useful metals. Many Norman hinges of wrought iron are still in existence, having a straight central bar or strap, with small scroll terminations; these central straps were strengthened with crescent shaped pieces, terminating in small serpent

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[2] Richard Glazier, A Manual of Historic Ornament, New York: Dover Publications, Inc., 1948, p.133.

forms, probably a survival of the Viking traditions. The art of wrought iron continued with the hammered and chiselled hinges and lock plates of varied and delicate workmanship, which enriched the beautiful Gothic chests of the 14th and 15th centuries. The simple wrought screen was being elaborated with foliage, cupids, and animals in pierced and hammered iron.

Brass

Monumental brass is much associated with England. At one time there were about 150,000 such brasses, of which only a fortieth part remains today.

Though the earlier brasses contain little but the figure of the deceased and an appropriate inscription, from about 1300 we meet the ornamental canopy, usually embellished with heraldic or symbolic motives. The Continental brass, whose background was of solid brass, had very lavish decoration. Fine examples such as those at Meissen, show a remarkable mastery over the material, and great minuteness of detail.

Enamelling

Cloisonne. This type of enamelling was in use in the early dynasties of Egypt, many large pectorals being found in the tombs. These usually are in the form of a hawk and are of gold or bronze. One of the most beautiful examples of Byzantine cloisonne is the Pala d' Oro of St. Mark's at Venice (A.D. 976). The earliest Chinese is at Nara and is of the 8th century; it reappears in the 13th and 14th centuries.

Champlive. This type of enamelling was practiced in Britain before the Roman conquest. The beauty of color of the early enamelled brooches, and trappings of horses of the early Britons and Celts,

show a fine sense of color and a harmony of lines and mass. Champlive was also used upon bronze shields, gold plate, and brasses.

Painted Enamel. In the 15th century painted enamels were introduced. The colors were now used as a pigment, and were painted and fired upon a copper plate.

Many fine miniatures in opaque enamels upon gold, remarkable for delicacy and perfection of enamelling, were produced by Jean Touten.

The finest enamels are those in which the enamel is used in small quantities, such as in the Celtic jewellery, the bookcovers, and the church plate of the Gothic and early Renaissance period.

Pierced, Chased And Engraved Metal Work

Especially since 1500 A.D. there has developed a great variety of pierced, chased, and engraved metal work. About this time the engraving, etching, embossing, and inlays of gold and silver came into favor. Highly ornate work of this kind is associated with the greatest armourers of the age, such as the Negroli brothers, or the Colman family.

Clasps, hinges, and mounts for various purposes, and cases for books also illustrated the engraving, pierceing and chasing of metal. Other fine work was done on locks, keys, clocks and watches, and metal mounts for furniture.

Revival Of Craftmanship

Revival of craftsmanship in the eleventh century is marked by one of the earliest technical books ever written. In his De Diversis Artibus, Theophilus summed up all that was known or could be discovered at that time for the benefit and instruction of his brother monks.

In the early Christian centures the monks comprised among their numbers the master craftsmen of the times. They controlled in their hands all the artistic work lavished on the churches during the Byzantine period. An age of persistent persecution succeeded in dissipating the Byzantine glory by the unlucky coincidence that in martyring a monk they may have unwittingly destroyed an artist and with him a valuable stock of technical knowledge.

The importance of the researches of Theophilus lies in the fact that they indicate an exact statement of the proficiency in craftsmanship enjoyed by the men of his day.

> Considering that the monk craftsmen were among the few people able to read and appreciate his manuscripts, his information was necessarily confined for the moment to the use of the religious orders. In after years, however, his influence was destined to spread over a wider area, and to include a less privileged set of conditions.[3]

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[3] Newton Wethered, Mediaeval Craftsmanship and the Modern Amateur, London: Longmans, Green and Co., 1923, p.3.

II. EARLY AMERICAN METAL WORK

The records indicate that the earliest manufacturing of copper, brass and tin vessels in the United States was in and about Boston, the first center of population in America.

As most of the homes of earliest New England picture a life of rigid simplicity, it seems reasonable to conclude that these vessels were extremely simple and functional in nature.

During the early seventeenth century many of the vessels later made of copper, brass or tin were made from iron. An Indian massacre in Virginia brought an end to the first attempt at manufacture as early as 1629. By 1650 two furnaces were regarded as successful in Massachusetts, and in these hollow ware was cast for household use. Sheet iron and tin were not available, their production requiring forges, plating mills or rolling mills, which did not appear until later. Some of the early wrought iron hardware may have been made from local smiths who obtained iron from nearby furnaces, but because of the difficulty of transportation and the scarcity of metal most of the seventeenth century ironware was imported.

> There was almost no seventeenth century production of copper in America, yet a few craftsmen of the period are known by name. Among them are Henry Shrimpton, William Mann, John Baker, and Shem Drowne (1683-1774), whose copper weather vane once surmounted Province House in Boston and is now owned by the Historical Society of Massachusetts. Because of the scarcity of metal these men must have been largely repair men.[4]

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[4] Henry Kauffman, Early American Copper, Tin And Brass, New York: Medill McBride Company, 1950, pp. 17-18.

Most of these men were trained in Europe, a fact which has an important bearing on the identification of early American copper, brass, and tinware. There is extreme difficulty, and sometimes the impossibility, of telling the place of origin of many pieces. One reason for this is that men trained in Europe were likelyto continue the styles and techniques which they had been taught. Also, a population so recently removed from its homeland would not be inclined to attempt a new and untried type of product.

Custom and pride caused the makers of pewter and silver to mark their products with their marks. The identification of copper, brass, and tinware presents further problems. It would be difficult for anyone to determine if a piece of sheet metal was fabricated in America or Europe. Furthermore, an American craftsman may have made a vessel from a sheet of European manufacture, which would nevertheless qualify as American-made. Few pieces are found that can be regarded as distinctly American in style or pattern or which can be declared so without further identification. Thus, the best and most conclusive way of identifying an American piece of metal is, in the case of copper or brass, to find the marks of the maker, which are rare, or in the case of decorative tinware, to establish a common pattern, such as is found on the tinware of Steven's Plains in Maine, or in parts of Pennsylvania.

Early American production at the beginning of the eighteenth century was accelerated by certain forces. First, the country was expanding; Philadelphia was rapidly becoming a great trading center; and the increased coastwise and foreign commerce stimulated economic growth. Sources of raw materials were being discovered, and methods

of processing were being refined and enlarged. In addition to the early furnaces, plating and rolling mills were constructed so that sheet iron was available for the making of sheet tin. Finally, a slow but certain nationalism was arising in the colonies, placing a premium on American-made goods.

The number of craftsmen who worked at the sheet-metal crafts during the seventeenth century was not large. America had no facilities for the production of sheet-metal, and it is well known that European countries did not look with favor upon the production of goods in the colonies. Eighteenth century mercantilism was based on the securing of raw materials from colonial sources and selling the finished product back to them, thereby both enhancing the economic status of industries at home, and keeping the colonies well in hand. It is evident that blacksmiths, silversmiths, and pewterers were working here at that time, but this can be attributed to the availability of a quantity of metal which could not be controlled by Europe as could the supply of copper and brass. By 1731 six furnaces for hollow ware and 19 forges or bloomeries were producing iron for the blacksmiths. The silversmiths, having secured their metal by reducing coin to bullion, hammered it into sheets before they shaped it into vessels. The pewterers probably had to depend to a large extent on securing discarded vessels and recasting them. Since it has been estimated that the life of a colonial pewter vessel in constant use was about ten years, the large inventories of pewter that went to America from England would indicate that there was an adequate supply of metal for re-casting.

Although copper was available in early times, due to the restrictions

placed on the colonies in regard to the manufacturing of copper and brass, it was many years before sheetmetal of local manufacture was available.

Among the first discoveries of copper in the English Colonies was that of Governor Endicott about 1648, the actual discoverer probably having been Richard Leader, who was in charge of the Saugus iron works and was familiar with mines.

In 1714 an old slave found, in New Jersey, a heavy greenish stone which he took to his master, who had it assayed and found it to be a rich specimen of copper ore. This Schular mine, as it was called, became one of the most famous mines of the colonial period; near the surface of the ground the ore was rich, and the yield was approximately 100 tons per annum. After thirty years of operation it attained such depth that it was no longer profitable, because of the difficulties of drainage.

When, because of its flood conditions, it could no longer be operated, a fire engine was shipped from England in order to drain it. This marked the first use of its kind in the mining industry. The unrest of the times preceding the revolution, however, curtailed the activities of the mine, and when the fire engine burned in 1773, it remained inactive for the next twenty years.

As late as the Revolution a quantity of copper ore was still to be found on the surface of the earth. It is said that Van Horne's Mountain in that state contained considerable ore, and a smelting furnace was erected near Bound Brook by two German refiners, who reduced the ore which the inhabitants collected on the surface or dug from the hill. A shaft was also opened in the side of the

mountain by a company which obtained much valuable ore from it. Two masses of ore weighing 1900 pounds were found there in 1754. These works were destroyed during the revolution.

The matter of producing sheetmetal was not so easily accomplished. But as the middle of the eighteenth century approached, evidence of the development of mines, the smelting of metals, and the production of craftsmen, became increasingly common. Newspaper advertisements in the more populous centers carried many more entries of craftsmen.

One of the first documentary records concerning the rolling of sheet copper in America states that there was a great need of skilled workmen, since the raw copper was not salable unless first prepared under the hammer. Later, rolling machines were imported from England which made it possible to get out copper with more convenience than by use of the hammer. The first specimens of Jersey-made copper were brought to Philadelphia just as Congress passed the non-importation act of 1775.

Apprenticeship

During Colonial times the metal workers were master craftsmen and knowledge and secret skills of the trade were passed on to apprentices. Often the son followed the trade of his father. In instances where there was no son, often a friend of the family was selected. In most cases the apprentice lived with his master, who was also bound to teach him reading, writing, and arithmetic, in addition to his trade. This procedure often ended in the marriage of the apprentice to the master's daughter, thus continuing business which otherwise might have ceased for lack of a male heir.

Apprentices were bound in the accustomed terms,

> "faithfully his master to serve, his secrets to keep, his lawful commands gladly do, as well as to refrain from the playing of cards, tables or other unlawful games."[5]

Seven years was the usual term of service. At the end of this time the apprentice had usually gained sufficient proficiency to take his place as a journeyman.

Development Of Factories

Most of the crafts such as coppersmithing, brazering, and tinsmithing, were combined in colonial times. As the businesses were small due to difficulty of obtaining material as much as to lack of demand for the products, the craftsman usually had his workshop within his home and also sold his wares there. As materials became easier to obtain and demand increased, workmen were hired and small shops were opened in which larger quantities of wares were produced. Although this was not mass production or assembly line method, it helped to bring about the differentiation of trades, which seems to foreshadow the coming of the industrial revolution with its specialization and interchangeability of parts.

The first factories, of necessity, were the ones which produced the sheet copper, brass, and tin. As previously stated, the production of iron, with plating and rolling mills had been underway for some time. Founding of brass was started in the seventeenth century and became firmly established in the eighteenth. Although several trades are involved in founding today, they were usually combined in the

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[5] Ibid., 26.

eighteenth century.

Slowly the advertisement of the craftsman changed to that of the merchant. The industrial revolution divided the duties of the business, and the man behind the counter no longer produced his wares as well as sold them. The intimate relationship of buyer and maker disappeared, and today is found only where occasionally a handicraftsman has been able to meet competition of the machines.

III. METALS AND ALLOYS USED IN ART METAL CRAFT

Malleability

The prime requisite for any metal used in art metal is malleability. Following is a list of the most common metals listed in order of their malleability:

Gold	Al
Silver	Tin
Copper	Zinc
Platinum	Lead
Iron	Nickel

The most common art metals in order of malleability:

1. Pewter
2. Copper*
3. Sterling*
4. Al*
5. Brass
6. Nickel Silver
7. Tin

Hardness-Soft to hard

The hardness of a metal is measured by the depth of a scratch made in the metal by a diamond point, under a given pressure or load. Given below is a list arranged according to their comparative hardness:

1. Lead
2. Tin
3. Al
4. Gold
5. Silver
6. Zinc
7. Copper
8. Antimony
9. Nickel
10. Platinum
11. Iron

*Pure metals; the rest are alloys.

Oxidization

The process by which metal loses its lustre and becomes tarnished is called "oxidization." This affects all metals except those regularly mined: pure gold, silver, and platinum.

Alloys

An alloy is made by the fusion of two or more metals, sometimes with the addition of non-metallic substances. The result of this fusion is that the alloy is harder, less malleable, and has a lower melting point than any of its components.

Melting Point

Most metals are composed of separate crystal masses of varying shapes in the different metals. When a metal is heated the tenacity of these crystal masses relaxes and the metal becomes softer and expands, if enough heat is applied the metal melts or changes to a liquid state.

The "melting point" of a metal is the point at which enough heat has been applied so that the metal changes from a solid to a liquid.

The familiar metals are listed below with their respective melting points for the Fahrenheit thermometers.

Mercury	- 39.5	Gold	1945.4
Tin	449.4	Copper	1979.6
Lead	621.8	Nickel	2645.6
Zinc	786.2	Iron	2795.
Antimony	1165.1	Platinum	3227.
Aluminum	1211.	Chromium	3632.
Silver	1761.8	Iridium	4262.
		Tungsten	6116.

Measurement Of Metals

Metals used in art metalcraft are usually bought in sheet form. These sheets are measured in thickness by "gauges." The Standard Wire Gauge is commonly used in the United States.

The most commonly used thicknesses of metal in metalcraft are No.16 through No.22. The gauge number and decimal equivalent of the seven most used:

Gauge	Thickness
16	.05082
17	.04525
18	.040303
19	.03589
20	.031961
21	.028462
22	.025347

The lower gauges, No. 16 to No. 18, are usually used in articles intended for practical use, and the higher gauges, No. 20 to No. 22, for ornamental projects.

Selection Of Metals

Cost, as well as malleability, especially in the school shop, is of great importance in the selection of art metals.

The metals vary in weight so this must be considered as well as the price per pound. For example: aluminum, because of its lightness, if bought by the pound, would provide material for more projects than the same number of pounds of copper. Metals, according to comparative cost per pound are:

Sterling silver, sold by ounce, most expensive

Pewter

Aluminum

Nickel silver

Copper

Brass

Tin Plate

IV. ART METAL PROCESSES

A brief description of art metal processes:

Hammered Work

The ornamenting of metal by hammering with the round end of a ball pein hammer or the rounded end of the chasing, planishing and fluting hammers. Different designs may be made by use of the different shaped hammers and by lighter and heavier strokes.

Fretwork and Pierced Design

Fretwork

In fretwork, the metal surrounding the design and any place within the design is sawed out.

Pierced

Pierced designs are made by simply piercing a small hole through the metal with a sharp point. The desired design is usually traced on the metal and outlined by piercing or pieced out itself.

Embossing or Repousse

This process involves raising designs in relief by depressing the metal from the back side. This is done by the use of chasing tools. The essential ones being: a narrow raising tool, an outline tool, a broad-raising tool and a background tool.

Chasing is the cutting of lines or flattening of the metal outside or within the design.

Forming

Pounding and stretching metal into desired shapes such as bowls and trays.

This may be done by shaping over an anvil or stakes of various shapes, but requires more skill, or by forming over a mold of the desired shape of the article.

Planishing

Planishing is truing and perfecting the shape of a bowl or object by placing it on a metal stake and hammering it lightly with a planishing hammer. This hardens the metal and makes small round marks on the metal which add a decorative effect. For flat surfaces the flat end of the chasing hammer may be used.

Fluting

Making slight depressions on the edge or brim of a bowl or ash tray. It is done by shapin g the metal into a groove of the desired size, filled or cut into the end of a piece of wood.

Etching

Etching on metal is done by applying a coat of black asphaltum to the design and etching the background with nitric acid, or by protecting the background and etching the design.

Soft Soldering

The most common soft solder is silver and half-tin and half-lead.

The only equipment needed are a soldering copper, the solder, a cake of sal ammoniac, and a flux.

The soldering is then done in the usual manner.

Coloring And Finishing

Coloring

Coloring and finishing may be done in a variety of ways. Some of the commonly used ones are:

1. Oxidation - usually done by passing the article back and forth through a blue flame. Also done with the use of acids.

2. Paint or enamel - an application of paint or enamel may be used.

Finishing

A desirable finish may be attained by:

1. Buffing with a machine buffer.

2. By hand, using steel wool and buffing powder and chamois skin.

Polishing does not protect the finish from oxidation, as to preserve the material color a protective coating must be used. A coating of wax or lacquer is the most common method.

Enameling

Enameling is one of the most beautiful of decorative arts.

They are divided into three classes:

Cloisonne

This type is done by soldering thin, flat wire of metal upon a plate of copper, forming cloisons or cells which are filled with the various enamels, in powder or in paste; then, in order to vitrify the enamel, it is heated in a kiln, if upon a flat surface, or by the aid of a blowpipe if upon a curved surface.

Champleve

Champleve enamel is formed by engraving, casting or scooping out the cloisons from a metal plate, leaving a thin wall or boundry between each cloison, which is then filled with the enamel as in the cloissonne method.

Painted

Early in the 15th century painted enamels were introduced. The colors were now used as a pigment, and were painted and fixed upon a copper plate.

V. THE IMPORTANCE OF ART METAL

In General Education

> Industrial Arts - One division of the "practical arts" with character and purposes associated with general education.[6]

Art Metal is a division of Industrial Arts and therefore plays a vital role in the achievement of its objectives. Few areas of Industrial Arts give the student a wider range of material to work with, or a greater number of simple manipulative experiences. It is an area in which every student will be able to experience creative pleasure, and a feeling of accomplishment as he forms metal into articles of permanent value and beauty. It gives opportunity for the student to create, using his own ideas in both designing and decorating the article.

Art Metal requires few expensive tools or shop equipment, and no special type of shop. The materials used, if selectively chosen, are relatively inexpensive and art metal can be, and usually is, taught in conjunction with other handicrafts.

With its wide use of industrial materials, and the opportunity it gives the student for individual initiative and self-reliance, and the present and future opportunity for use as a recreational hobby, art metal plays an important role in general education.

As A Hobby

Leisure is an increasing segment of the "American Way" of life. Industrial Arts is playing an important part in the preparation of our future citizens to develop worthwhile hobbies and recreational activities.

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[6] John Friese, Course Making In Industrial Education, Peoria, Ill.; The Charles A. Bennett Co., Inc., 1958. p.7.

Unfortunately, many adults of today have not had the opportunity to learn how to enrich their leisure time with a hobby that is both constructive and enjoyable.

Art metal, as a hobby, is an opportunity for the release of inner urges for expression of imagination, development of art appreciation, as an outlet for the natural desire for the manipulation of tools and materials, and the desire to make things.

In many cities adult education courses are sponsored by the schools. Some of these courses are academic but many fall into the hobby or recreation category. If craft courses such as these aren't available, the low cost and the small number of tools needed, make art metal an ideal home-shop hobby.

The amateur is not interested in a craft as a means of livelihood, but is actuated purely by a love of making things, of attempting experiments, of pursuing a course of discovery, which excites his inventiveness, or satisfies his craving for a fresh amusement. He is the man who can afford to do things for pleasure which cannot be done for profit.

The contributions of art metal and other handicrafts in the combating of juvenile and adult delinquency should not be underestimated.. By keeping youths and adults pleasantly occupied during their leisure time, art metal contributes to the mental, physical and social health of the individual.

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APPENDIX

SELECTED LIST OF EARLY AMERICAN METAL PRODUCTS

1. Lamp
2. Brass mortor and pestle
3. Andirons of brass and iron
4. Weather vane of copper
5. Copper and brass tea kettles
6. Oil container
7. Copper warming pan
8. Copper sauce pan
9. Tin coffee pot
10. Brass ladle
11. Copper brazier
12. Brass coal hod
13. Copper fish kettle
14. Copper measure
15. Copper still
16. Copper rain spout
17. Tin apple tray
18. Pierced tin grater
19. Tin foot warmer
20. Food warmers of tin
21. Tin pails
22. Tin candle box
23. Tin oven
24. Cookie cutters
25. Tin basin
26. Tin nursing bottle
27. Tin wine press
28. Tin candle holders
29. Chandelier
30. Tin candle molds
31. Tin lantern
32. Brass buttons
33. Plaques
34. Brass hardware
35. Horse bells
36. Brass rifle parts
37. Brass clock works
38. Brass surveyor's compass
39. Brass sundial
40. Bronze molds
41. Brass mold
42. Iron cranes
43. Powder canisters
44. Pepper boxes
45. Speaking trumpets
46. Plate covers
47. Cream skimmers
48. Cake pans
49. Funnels
50. Girdle stoves
51. Snuff boxes

GENERAL EQUIPMENT AND TOOLS

A listing of equipment for art metal work includes the following:

1. Work bench - of height desirable for size of student.
2. Anvil - small to medium size.
3. Shears - straight and curved blades.
4. Saws - hack saw and jewelers.
5. Hammers - ball pein, chosing
6. Mallet - wooden, forming mallet.
7. Files - variety of shapes, size and degree of coarseness.
8. Scriber.
9. Dividers.
10. Stakes - rounded metal and wooden.
11. Twist drills - small sizes, few larger.
12. Chosing tools - outline, narrow raising, broader raising and background.

Many new tools for specific uses may be purchased, but for simple projects, and in starting or setting up an art metal area, the above listing will suffice until need for more specialized tools is indicated.

SELECTED LISTING OF ART METAL SUPPLIERS

American Handicraft Co.
83 West Van Buren St.
Chicago 5, Ill.
2217 Olive St.
St. Louis, Mo.

Brodhead Garrett Co.
4560 East Seventy First St.
Cleveland 5, Ohio

Cleveland Crafts Co.
4707 Euclid Avenue
Cleveland 3, Ohio

Hubbell Metals, Inc.
2817 Laclede Avenue
St. Louis 3, Mo.

Industrial Arts Supply Co.
P.O. Box 5438
Minneapolis, Minnesota

Metal Goods Corporation.
640 Rosedale Avenue
St. Louis 12, Mo.

Retco Alloy Co.
1328 East Seventy Fifth St.
Chicago, Ill.

W.D. Allen Manufacturing Co.
566 West Lake Street
Chicago 6, Illinois

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