Silver plate, XVIth century

In Metropolitan Museum, New York City.

ART METALWORK

WITH INEXPENSIVE EQUIPMENT

FOR THE PUBLIC SCHOOLS
AND FOR THE CRAFTSMAN

By ARTHUR F. PAYNE
Assistant Professor of Manual Arts,
Bradley Polytechnic Institute
PEORIA, ILLINOIS

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FOREWORD.

Among the leading teachers of the manual arts in the schools there is a growing interest in art metalwork. This is due in part to a recognition of the increasing importance of metal as a material of construction in the arts and industries, in part to the fact that by adding it to woodwork, which is the more common form of handwork in the schools, experience in tool processes becomes broadened and enriched, but chiefly it is due to the fact that art metalwork adds to handwork instruction a valuable means of art expression. The opinion is now general that manual training should lead out beyond the mere mechanical and utilitarian into the realm of graceful, free expression of beauty of form and color and design. Because metal is so free from troublesome grain, because it is so ductile and easily shaped under certain conditions and so rigid under others, because it is so capable of pleasing effects of color and finish, and because of its relation to the natural sciences, it seems preëminently fitted to become one of the most popular of the materials of art expression in the schools, while at the same time serving as a medium for training in manual dexterity.

In order to make art metalwork available and profitable in the schools it was necessary that it go thru the same process of pedagogical analysis as the other manual arts subjects have gone thru during the past thirty years. It was necessary that the fundamentals of the art be selected and organized into a course of instruction; that this be done with reference to the cost of equipment, the expense of materials to maintain instruction and the limitations of instruction in large classes; and that all this be done in the light of the best modern pedagogical methods. To accomplish this required practical familiarity with the craft, training in pedagogy, experience as a teacher, and power of accurate description. It is believed that all of these requirements have been met in a very happy combination and proportion in this book. The fact that the instruction here outlined has already been successful in awakening in hundreds of high school boys a lasting interest in artistic handicraft and completely changed their attitude toward their own power to design and produce works of real merit which gave them pleasure is substantial proof of the educational value of such a course of instruction.

CHARLES A. BENNETT.

PREFACE.

Ever since the introduction of manual training into this country it has been in a continual state of growth and adjustment. Wood has always been the principal medium and while there are numerous schools that have established expensive machine-shops, foundries, and forge-shops, there still remain the large majority of schools where the expense of equipping such shops is prohibitive. These schools feel the need of a new medium, and an enlargement of the field of tools and processes, and they are turning to art metalwork as a solution of their problem, because of the inexpensive equipment required, its perfect correlation with design and drawing, and the easy, almost unconscious, acquirement of knowledge by the student in the fields of chemistry, mineralogy, art, metallurgy, and physics.

The problems presented in this book follow the lines of the best technical methods derived from experience as a practical silversmith, and the illustrations used are almost entirely the work of students who worked under regular manual training school conditions. They adhere to the principles of the arts and crafts movement, that the elements of design should be considered in this order: the object must be suited to its use; the construction must be honest and sound; the decoration must be adapted to the material, tools, and processes, and must in nowise interfere with the use or weaken the construction of the object. The problems are given in such sequence that the old tools and processes are reviewed, and at the same time new tools and processes are introduced in each new problem. This is one of the fundamentals of pedagogy, that must be considered when outlining any new course for school work.

It is hoped by the author that those instructors who make use of this book will also make use of and develop the correlations that have been suggested here, and that are further developed in the text, thereby enriching the content of their courses.

All of the designs and practically all of the work used as illustrations in this book are the products of students who worked in classes of twenty or more under ordinary school conditions. It would have been a much easier matter to use as illustrations the best work of well known craftsmen, but it was felt that that method would react unfavorably in that it might discourage some from attempting the work at all, and cause others to begin on designs or pieces that they would not be capable of accomplishing.

Finally, I wish at this time to thank the students of Bradley Polytechnic Institute and of The Arts and Crafts School of Columbus, Ohio, and private students at other places, for the many helpful suggestions received, and for the photographs of their work. Without the inspiration of these students this book would never have been written.

Arthur F. Payne,
Peoria, Illinois.

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PART I

MATERIALS AND EQUIPMENT

Chapter I

THE INFLUENCE OF THE ARTS AND CRAFTS MOVEMENT UPON MANUAL TRAINING

Enough has been said about the arts and crafts movement since its inception, to run the entire gamut of human opinion. But there is one phase of its influence about which very little has been said, and that is the vitalizing influence it has had upon manual training in our public schools. And if it had done nothing but exert this influence, that alone would be sufficient reason for its existence. At the present time the principles of the arts and crafts are being spread thruout the land thru the medium of manual training more rapidly and surely than would ever be possible by the supporters of the arts and crafts movement alone.

To realize fully the influence that the arts and crafts movement has had upon manual training, we must know a little of the type of work done in manual training before it felt the influence of the arts and crafts. The first manual training problems shown in this country were at the Centennial in 1876; they were sent here from Russia, and consisted largely of the common joints used in carpentry, and consequently were totally devoid of any artistic element whatever. The adoption of this system into our schools was the beginning of real manual training in this country. The problems were merely exercises and were of no utilitarian value whatever; they were the essence of monotony, and speedily killed any interest that the student might have had in manual training. Next came the Swedish sloyd; this was a decided step in advance because it took into account the interests of the students, by using models that were of use in the home. But still the problems were devoid of any art interest. Dr. W. T. Harris, the well-known educator, said of the Swedish sloyd, "Sweden is the leader in the manual training movement, but her educators have not yet seen the importance of developing correct taste among their workers, as a condition of industrial success; clumsy shapes and incongruous ornaments are the characteristics of Swedish goods." This statement by one of the leading educators of that time shows clearly that they felt the need of the combination of design, more artistic appreciation, and the higher ideals that the arts and crafts movement later furnished to them.

It is thru the direct influence of the arts and crafts that educators now realize the educative value there is in design thru the necessary logical thinking required to produce a design that has embodied in it the requirements and limitations of use, process, and material. Where the shops and the design class have no vital connection, a student can design things that are impossible of execution, and they are accepted providing they look well on paper. But where the arts and crafts principle is in force, where the designer and the teacher have a working knowledge of the processes and material involved, and the things designed are made in the shops, there we get a directness and simplicity of design that is entirely different from the incongruous objects that are produced in the classes where the teacher is strong on art (so called), but whose knowledge of structure and materials is weak, or in the classes of the teacher whose knowledge of design is limited to the ornament that he copies and applies promiscuously.

Thru design we appeal to the interests of the student; this develops the much desired active and creative attitude in the student, instead of the dormant receptive attitude. Thru it we get a definite reaction that is a pleasure to the student and an inspiration to the teacher.

Since the adoption of manual training into the schools of this country, we have been informed upon its educational values. later of its ethical and industrial values, but the arts and crafts movement has showed to us its art and its social values. It has given to manual training artistic appreciation and higher ideals, and the unification of structure and decoration that we find in the progressive manual training shop of today. John Quincy Adams said "The purpose of art is to idealize work," and that is what we find in the manual training shops that keep the principles of the arts and crafts in view.

THE MISSING ELEMENTS SUPPLIED

The criticism that is being made nowadays of our school system is that it has no vital connection with our economic or social system, and that it has not kept pace with the development of commerce and industry; also that it has no ethical or social value to the great majority of people. The development of manual training by the making of objects of real value, constructively sound and artistically good, develops the ethical value, and increases very largely the value of our school system to society.

The entire reorganization of society and industry upon the principles set forth by the founders of the arts and crafts movement is impossible. The education and elevation of the great public to an appreciation of even that which is possible cannot be done by a few scattered enthusiastic disciples of Ruskin and Morris. This education and elevation is a function of the school system, and that it was started and its propaganda disseminated entirely outside of the school system shows that the criticisms of our schools that are current today are worthy of serious attention by progressive educators.

Even the foremost and the most progressive of our educators can learn something from a study of the social and industrial phases of the arts and crafts movement. The men who are so earnestly advocating vocational education in an endeavor to bring the school system into articulation with our social, economic, and industrial system can learn that art, drawing, design, and industry cannot be separated but must be developed together. The average educator when considering the vocations from his somewhat narrow point of view engendered by his experiences with manual training rather than the vocations, thinks of the machine-shop first, and of forging, foundry, and pattern making, as adjuncts of the machine-shop; he thinks of joinery and carpentry, and thinks there is no need for art or design here. But he should visit one of our large stores where the products of many vocations are presented for sale, and he will find it impossible to pick out one piece of work that does not have embodied in it design or a need of design. The vocational schools for girls are realizing this need much faster than those for boys, as in most of the textile, dressmaking, and millinery courses we find a parallel course in applied design and the history of costume. By correlating design with the vocational, educators can meet the criticism that is already abroad, that the suggested vocational courses have no cultural element in them. In one new school that the writer visited a few weeks ago, in the class that was cataloged as the millinery class, the girls were learning millinery, practical design, history of art, and French history. Such a course as this is more truly cultural than any of the traditional academic courses could possibly be and it seems to be a truly practical realization of the teachings of Ruskin and Morris by the agency that should do it, namely the public school system.

William Morris protested against the minute division of labor and the inconsistent design arising from such division, and the exploitation of labor arising from making things merely to sell. We have the same conditions today, and his large vision and high ideals are being lost sight of by arts and crafts workers themselves; but they are almost unconsciously being adopted by the progressive manual training teacher who knows construction and design, and has been trained to analyze a problem or a course of study and reduce it to its educative, ethical, cultural, and social values.

Today the great need of the arts and crafts movement is an educated and appreciative public, and that is the return that manual training will make for the enrichment of the work that has been derived from the arts and crafts movement. Manual training is educating and training a generation of future buyers, who will demand sound construction and consistent ornament in the things they buy and the houses they live in. The combination of the two movements will result in the development of both and the enlightenment of the public and benefit to the state.

Chapter II.

THE CORRELATION OF METALWORK AND DESIGN.

Until a few years ago design was taught with only pencil, paper, and a little color as the necessary materials. At the present time we use clay, leather, wood, reed, raffia, and textile materials, iron, copper, brass, and silver, and all the tools necessary to the proper working of the materials. Until recently a design was called good if it looked pretty on the paper or if it were well drawn, and the question of the use and of the construction seldom entered into the consideration of the problem. Nowadays, while good drawing is a requisite, the standards by which a design is judged are: *First,* is it suited for the use and purpose for which it is designed? *Second,* can it be made in the manner designed, and of the material indicated in the design? *Third,* is the indicated construction sound, and will the article be durable if constructed in this manner? *Fourth,* is it a suitable article for decoration? *Fifth,* is the decoration based on the structural elements of the design? *Sixth,* has the decoration been conventionalized to conform to the limitations and requirements of the tools and processes?

It is not to be expected that grammar or high school students will all make excellent designs, even with the best of teaching. Even the very best professional designers make dozens of designs before they get one that will fulfill all of the requirements and limitations. All designers, whether amateur or professional, have a definite problem with certain limitations and requirements, and it is the business of the manual arts teacher to give to the student a definite statement of the problem, and to have the student work it out under instruction, taking into consideration the requirements of use and sound construction, the limitations of material, the time involved in the making, and the skill and ability of the student who is to carry the design to its completion.

Design is a subject that has its fundamental principles, its rules, and formulas, and it must be taught as such, and not in a hazy or indefinite way. The problem should be presented to the student as definitely as a problem in mathematics and when a student is asked why a certain design is good or bad, he should be able to answer, because it violates or conforms to this or that rule.

Metalwork in copper, brass, or silver is a subject that is coming rapidly to the front in the manual arts and it is inseparable from design. In it we have means of expression for the art of design that is almost perfect, lending itself readily to constructive design, to line, and form, as in bowls, vases, etc., and to the use of characteristic forms of construction as a means of decoration, as in lanterns, candlesticks, and electroliers, or in similar problems where rivets or lapping is used as a means of construction. It lends itself also to the study of spacing and proportion, as in the side of a lantern, or the parts of a candlestick, or the border of a plate; to surface decoration in etching, sawpiercing, hammering, chasing, enameling; and to coloring by means of heat or chemicals. Metalwork has a decided advantage in the fact that there is no danger of breakage, and in the ability of the metal to stand a repetition of nearly all the processes over and over again until it is right. Even when an article is finished we can go back and repeat the processes and change it entirely from what it was in the first place. Other advantages are the low cost of the necessary supplies, the simple and inexpensive equipment, the fact that elementary work may be done without benches, and that it can be done with equal facility by both sexes.

The first problem suggested is that of a watch-fob or bag-tag made of copper or brass, and the first instruction in the designing of this problem, as with all of the other problems, should be in explaining and illustrating the constructive and utilitarian requirements. This may be done by holding up a small piece of copper and a strip of leather, and leading the class to see that a hole in the copper for the leather to pass thru and fasten to is necessary before it can be even the simplest kind of a watch-fob,—bringing out the rule that construction must be thought of first. Next is the size of the fob. Some pieces of cardboard cut in squares or rectangles, some too large and some too small, and some about the right size for a watch-fob, should be shown to the class. The students should be led to see that the fob must not be too large or too small, but that it must be of a practical size. After we have decided on the size, then we have to design the outline or shape. Starting from the square or the rectangle, show how the shape may be varied and made more interesting by cutting or rounding off the corners. Then cut off the bottom corners more than the top corners developing into the triangular shape; then round off the corners and show slight curves instead of straight lines. During all of these trials keep before the class the importance of the strap hole.

After we have determined the outline we have arrived at the stage where the decorative design must be considered. The process of etching it on the fob places a limitation on us, in that we must leave the metal full thickness around the edge and around the strap hole to avoid making the fob weak. This brings out another rule, that the decoration must be subordinate to the strength and utility of the article decorated. Then come three rules together: *first,* that we should have a center of interest or point of attraction for the eyes and attention to rest upon; *second,* that the design must support or follow the shape; *third,* that the various parts of the design should harmonize and hold together and not look as tho they had been sprinkled on. A small square mirror is of great help at the stage. It is made use of by folding the drawing paper to make a crease, then opening it out and again and drawing one-half of the design on one side of the line and placing the mirror on the center crease. The complete design will be seen reflected in the mirror, by slightly moving the mirror one way or the other the design can be varied. This brings into use an important principle of design, that of symmetry or like-sidedness, where there is perfect balance on each side of the central line. This principle may be illustrated to the class by drawing meaningless lines or letters and figures and placing the mirror on them. Suggestions for designs will be shown that will interest and often help the students.

The designing of the next problem, the paper-knife, is similar to that of the watch-fob, and gives further practice in the rules and principles of design already familiar. The added feature of raising the center to give stiffness and strength to the knife gives further emphasis to the rule that construction and utility should dominate.

The next problem, the hat-pin, gives us further limitations and an opportunity to demonstrate the principles of radiation and four part symmetry which may be presented in this way: explain that a hat-pin design is best which has no up or down, and has the point of interest in the center with the design radiating from that center. Radiation also tends to make a design more united. The principle of radiation may be illustrated to the students by the use of two mirrors used in this manner: Draw a one-fourth section of the design, and on the quarter lines place the two mirrors meeting at the center, and the design will be mirrored entire. There is a special advantage in the use of the mirrors as they obviate the necessity of drawing the entire design to see whether the design is pleasing or not. If the design is pleasing the paper can be folded on the section lines and rubbed over on to the other sides, saving time and labor and giving the students more inducement to draw more and varied designs.

Passing over the other problems, the tie-pin, belt-pin, cuff-links, and desk-pad corners, which give further practice in the rules and principles involved in the fob and paper-knife, also the blotter, which gives more practice in radiation and in two- and four-part symmetry, we come to the problem of designing the book-ends. Here we can show the points of force and growth of the design, and the need of stability in the design at the bottom to avoid the appearance of top heaviness.

In the candlestick is brought out the general rule that the height should seldom be more than three times the diameter of the base. To give practice in good proportion draw on the blackboard a candle socket and pillar; then draw a base that is plainly too wide, and one that is too small, gradually working out two limits of size, one that is large, but would not do if it were larger, another that is small, but would not do if it were smaller. Then you have a choice anywhere between these two limits. In this way is brought out the innate sense of good proportion that nearly every person has if he can be brought to realize it, also the absolute necessity for considering the method of construction, and the advantage obtained by using any of the characteristic forms of construction as a feature of the design.

Passing over the problem of the lantern, which gives further practice in the principles involved in the candlestick, we now have a problem in line and form in the designing and making of a small simple bowl. One method in teaching the proportion of curves is to draw on the board a few curves and show that the curve that starts with a long sweep and changes near the end to a sharp curve is the best. Lines which are too even in their curvature never have character or strength. Those that start nearly straight and end in a sharp curve show life and spirit. There should also be beauty of proportion between the long and the short curve; as a general rule the sharp curve should take the smallest part of the line and the long curve should be from three to seven times as long. In the bowl form, it is usually best when the proportion of the short curve to the long curve is one to three; that is, the short one-third and the long curve two-thirds of the entire line. We also have to consider, and are limited by, the tools used in this first problem in "beating up" or "raising" a form. All broken interrupted lines are to be avoided and we must strive for a smooth, graceful bowl form of good proportion. This problem may be made more interesting by designing a border to be etched near the top edge of the bowl.

The next problem is that of the round plate, from 6″ to 10″ in diameter. To obtain the proportion of the border, draw on the blackboard a circle representing the diameter of the plate, then draw a border that is evidently too narrow, then one that is too wide, and gradually establish limits in the same way that we did in the candlestick base. It will be found, however, that the best proportion will be obtained when the border is from one-fifth to one-seventh of the diameter of the plate.

Now we may design a decorative pattern to be etched on the border. There are five possible ways in which this may be designed: *First,* the design units radiating from the center outward; *Second,* radiating from the rim towards the center; *Third,* moving around the border, but with the attention centered at the outer edge; *Fourth,* moving around the border, but with attention centered at the inner edge; *Fifth,* moving around the border with the center of attention equally divided between the inner and the outer edge. In designs which move around the border it is best to have them move or grow to the right. The mirrors are of great help to the student on this problem, as it is necessary to draw only one section, by placing the mirrors on the section lines meeting in the center the entire design will be reflected in the mirrors.

The next problem is that of the nut-bowl, which gives further practice in line and form, as in the small bowl, with additional design problem of making pleasing vertical divisions. These will be carried out by "crimping," "fluting," or "paneling." Draw on the board a circle representing the diameter of the bowl and divide it into a pleasing number of sections; five, six, or seven divisions will be found the most satisfactory.

In this necessarily brief statement it is impossible to give even a general review of the numerous definite rules and principles of design applied to metalwork. It is simply an effort to show in a general way a method whereby design may be correlated with metalwork in eighth grade and first and second year high school classes, working under regular school conditions where a definite method of procedure must be pointed out to the student to secure the desired result.

Chapter III

COPPER

I. HISTORICAL

Copper is one of the six metals mentioned in the Old Testament, and is the most important of the seven mentioned by ancient historians. It was known and used by the people seven generations after Adam, as we are told that Tubal-Cain was the instructor of every artificer in brass and iron.[1] Greek historians relate that copper was found by Cadmus on the island of Euboea, near the town of Chalkos, and copper is called *chalkos* by the ancient historian Homer in his writings.

The Romans knew copper by the name of *cyprum,* which was later changed to *cuprum,* both names being derived from that of the island Cyprus in the Mediterranean Sea, where the Phoenicians had mined copper at a very early date. The island of Cyprus was dedicated by the ancients to the goddess Venus and copper later came to be known by the astronomical sign of the planet Venus, ♀.

The English word *copper,* the French *cuivre,* and the German *kupfer* were introduced into those languages about the tenth century and are modifications of the old Latin *cuprum.*

The old Hebrew manuscripts make no distinction between pure copper and the alloy with tin which at the present time is known as bronze, but which the translators rendered by the word brass. This alloy could not have been made use of until long after copper was known and used, because tin was not found in the countries bordering on the shores of the Mediterranean. It could not have been used, therefore, until trade with Western Europe had been established, when the Phoenicians brought tin from Britain.

Euboea and Cyprus have already been mentioned as furnishing the Greek and Romans with copper. Spain also supplied them with copper; in fact, some of the same mines are being worked at the present time. The Egyptians drew their supply of copper from Arabia, and it is supposed that one of the objects that Rameses the Great had in view when he dug the canal across the isthmus

[1] See Genesis 4:22.

of Suez about the year 1350 B. C. was to connect the copper producing territory of the Arabian peninsula with his kingdom on the Nile. Even at the present day archeologists find traces of mines buried in the sand and in them tablets bearing inscriptions proving them to belong to an age that is almost beyond the reach of the historian.

The Israelites had bronze weapons in the time of King David. Homer, the Greek poet, represents his heroes as fighting with arms made of bronze. The Colossus of Rhodes, one of the seven wonders of the world, an enormous figure of a man that stood across the entrance to the harbor of the ancient city of Rhodes, was made of bronze. This figure was completed in the year 280 B. C., was about 110 feet high, and is a remarkable proof of the abundance of copper and of the skill of the workers of that early date.

When the Spaniard Pizarro conquered Peru in 1533 he found that they were well acquainted with the properties of copper and bronze, and used the alloys of copper and tin to make the tools that they used in building the vast aqueducts and temples for which they are famous.

Masses of the tough native copper detached by water from their original beds and deposited in the beds of streams where the natives went to obtain stones to make their weapons and tools, would, by reason of their weight, color, and malleability, attract attention. Then the step to the alloying with tin would readily follow.

The earlier money of the Romans was of bronze, and sometimes of an alloy of copper and zinc, now known as brass. During the reign of Julius Caesar, about 95 years before the birth of Christ, coins were made of pure copper.

During the middle ages, beginning about the ninth century, we find a very important use of copper and its alloy that developed with the rapid spread of the Christian religion. Church bells which are made of an alloy of copper and tin are first made mention of in the church records of the seventh century. They were brought into general use by Charlemagne, king of the Franks, who in the year 800 was crowned Emperor of the Romans by the Pope and took the name of Carolus Augustus.

The use of bronze in tools and ornaments was most fully developed by the Danes, but the most beautiful forms were found in Scandinavia. They made use of this alloy in making richly ornamented pins, buttons, clasps, rings, bracelets, and trumpets.

In the construction and ornamentation of churches, copper, bronze, and brass have played an important part; the altars, tablets, and sepulchral statues were often made of these substances.

The improvements in the manufacture of gunpowder and the consequent greater use of bronze cannon during the reign of King Edward the Third of England (1312-1377) had an important influence in increasing the value and the production and use of copper; and as we come down to the civilization of modern times there is scarcely a branch of human endeavor where copper is not found as an important means of attaining greater perfection. Either unmixed, or in the form of its numerous alloys, it is employed in the construction of nearly all kinds of machinery, and for forming the delicate instruments of the astronomer and engineer. It is an indispensable part of the huge electric generators and dynamos, and it furnishes a valuable reagent for the chemist. It is used in large amounts in ship building, and it furnishes a basis for dyes. Almost every advance made in the arts and sciences adds to the number of its applications.

II. PRODUCTION OF COPPER

Copper and its alloys are the first metals that we find any mention made of in history, and there are numerous objects made of copper or its alloys in existence today that the leading archeologists claim date back to 3,000 years before Christ. But of the modern important producing fields only Spain, Germany, and Japan have a history that began earlier than 1835.

The first copper discovered in the United States was found in Massachusetts in the year 1632. In 1709 a company was organized in Granby, Connecticut, for the purpose of working the Simsbury copper mine, but only a small amount of copper was taken from this mine. Work was started on the copper deposits of New Jersey during the year 1719. The mines in Vermont, opened in the eighteenth century, were the principal source of American production until the real opening of the mines in the Lake Superior region in 1884.

The Jesuit missionaries discovered the Lake Superior mines in the latter part of the sixteenth century. An English company was formed and the mines on the Ontanagon river were worked in 1771, but the men were killed and the mine was abandoned. Copper mining was begun in Tennessee in 1850, neglected during the Civil War, and resumed in 1890.

The really important copper mining of the United States dates from 1884 with the first production of a few tons of black copper ore, probably Chalcocite, taken from a mine at Copper Harbor, Michigan. The beginning of the Lake Superior copper industry was very crude, but the growth was steady from the start, and within twenty years these mines became the most important producers in the country, and second only to the mines of Chili. The existence of the rich copper fields of the Lake Superior district was known to the American Indians, and it is certain that these mines have been worked by some prehistoric race, as they have left many traces of their operations.

Montana is now the largest copper producing district in the world. The first copper was produced there in 1882. Copper was found in Arizona in 1872.

Speaking broadly, the great copper industry of the twentieth century may be said to date from the middle of the nineteenth century. The great copper producing fields of today were unknown in 1840. Mexico, which comes after Montana as the world's greatest producer, mined only small amounts previous to 1875. The present copper industry of Canada is so recent that all of its principal developments have occurred since 1880. Australia and South Africa produced their first copper in 1850, and production along modern lines began in Chili at the same time.

The United States produces more copper at the present time than any other country. The total amount produced in the United States during the year 1911 was 1,090,000,000 pounds. This was about 65 per cent of the total amount produced in the entire world during that year.

III. THE ORES OF COPPER

There are nearly 200 distinct copper ores, but the principal copper ores of commercial importance may be divided into seven classes, as follows:

Native copper, existing alone or practically so, as in the Lake Superior district, Bolivia, and elsewhere, and occurring in the oxidized zone of copper mines in almost every mineral field.

Oxide ores, of which Cuprite and Melaconite are good examples.

Carbonic ores, as Malachite and Azurite. These two ores are largely used as semi-precious gems, when pieces of sufficient hardness are found.

Sulphide ores, of which Chalcocite, Bornite and Chalcopyrite are the most important.

Sulphate of copper, as Chalcanthite, which occurs as an alteration product in many rich sulphide mines, and which is the source of the copper secured by precipitation from cupriferous mine water.

The Arsenides, of which Enargite is the most important.

The Chlorides, of which Atacimite is a good example.

In commercial importance, the sulphide group is easily in the lead, about three-quarters of the world's copper supply coming from ores of this class. Of this group Chalcocite alone produces nearly one-half of the world's supply of copper.

Next in importance commercially is native copper, which is mined extensively in the Lake Superior district.

Third in importance are the carbonates, Azurite and Malachite being the only ones found in large quantities. Malachite is the most important, as it is rich in copper and is easily smelted.

Most copper deposits carry both gold and silver, usually in small quantities, but frequently in amounts sufficient to add materially to the value of the mine. Lead and zinc are found very commonly in connection with copper ore, the three sulphide ores of copper, lead, and zinc being closely affiliated. Iron, while very rarely a commercial product of copper mines, is found in varying quantities in the great majority of copper mines.

Many mines have been opened for gold that really contained immensely greater values in copper at depth. There are frequent instances of gold mines turning into copper mines, the most recent example of importance of this change in metallic values being afforded by the Mount Morgan mine of Queensland, Australia, which for many years was one of the largest gold producers of the world, and which is now a copper mine of great value.

Examples of silver, lead, or zinc mines changing into copper mines at depth are numerous in Utah, Mexico, and elsewhere, the best examples being furnished by the mines in the Bingham district of Utah. The zinc ores of the mines at Leadville, Colorado, are replaced at depth by copper ores.

The Red Jacket shaft of the Calumet and Hecla mine in Michigan is the deepest copper shaft in the world, 4,920 feet.

The principal ores of copper with the approximate percentage of copper found in each is as follows:

Cuprite, a copper oxide which contains 89 per cent of copper. This is the ore that is richest in copper, frequently shading to crystals of native copper.

Chalcocite, a copper sulphide containing 80 per cent of copper. This is the richest commercial ore of copper, and it yields more than one-half of the world's entire copper supply. It is found in all copper districts.

Chalcopyrite, often called copper pyrites, or yellow copper ore, a copper and iron sulphide which contains 35 per cent of copper and 30 per cent of iron. This is the primary ore of copper, all other ores of copper being derived from it. It is found in all the copper fields of the world, and is second to Chalcocite in importance as a commercial ore of copper.

Enargite, a copper sulphoarsenite bearing 48 per cent of copper. This is the most common and valuable ore at the largest copper producing district in the world, Butte, Montana.

Bornite, a copper and iron sulphide bearing 56 per cent copper, 16 per cent iron, 28 per cent sulphur, is another of the important commercial ores.

Azurite, sometimes called Chessytite or blue carbonate of copper, a copper carbonate with 55 per cent of copper. This is an ore of a most beautiful dark blue color, and is very largely used as a semi-precious jewel.

Malachite, a copper carbonate containing 58 per cent of copper, It is seldom found in large enough quantities to be of value as a commercial ore. It is dark green in color and the compact pieces are valued as semi-precious stones.

Adgadonite, a copper arsenide found in Chili and the Lake Superior district, bearing 85 per cent of copper.

Horsfordite, a copper antimonide with 76 per cent of copper, found in Asia Minor.

Covellite, a copper sulphide bearing 66 per cent of copper. This is a valuable commercial ore, found in Utah, Wyoming, and a few other localities.

Chrysocolla, a hydrous copper silicate with 36 per cent of copper. This ore is valuable as a commercial ore and also as a semi-precious stone for mounting in jewelry.

Stannite, a copper, tin and iron sulphide, with 30 per cent copper, 13 per cent iron, and 27 per cent of tin. It is found in Ireland and England.

IV. METHODS OF OBTAINING COPPER FROM ITS ORES

There are three general methods of extracting copper from its ores. The dry, wet, and electrolytic methods. The wet method is used the least of the three, and consists in placing the ores in an acid solution which dissolves the copper, which is then precipitated to the bottom of the tank by the addition of suitable precipitants.

The dry method is the one generally used for reducing the ore, especially when it is rich in copper. This method consists of two operations; *First*, roasting the ores; and *second*, smelting the roasted ore in a blast furnace.

The ore is first "heap roasted" out of doors, the fuel being wood. One cord of wood is all that is necessary to roast 40 tons of ore. The wood is placed so as to form chimneys thru the ore pile. The wood is then fired, and the burning wood releases and sets fire to the sulphur of the ore which burns and again releases more sulphur. In this manner the "roasting pile" will burn for several weeks.

In copper smelting two kinds of furnaces are used, blast furnaces, and reverberatory furnaces. The smelting of copper ore in a blast furnace is the process of reducing the copper from its ores by subjecting the ores to a fierce heat in a cupola. Coke is the fuel used, and the fierce heat is obtained by turning into the cupola a blast of air heated to about 800 degrees Fahrenheit.

The largest blast furnace in this country is at the Washoe Works of the Anaconda mine, in Montana. It is 80 feet long, and has a capacity of 2,700 tons of ore a day.

The reverberatory furnace is one in which the heat from the fuel is reflected back again to the ore, giving a steady but less fierce heat. The reverberatory furnace is used on the sulphide ores in preference to the blast furnace, as sulphur contained in the ore assists in the reduction of the ore. The first reverberatory furnace for copper smelting was built in 1765 in Yorkshire, England. The largest reverberatory furnace is at the Anaconda mine in Montana. It is 119 feet long, and has a daily capacity of 300 tons of ore.

The Bessemer converter is a type of blast furnace that is also used in smelting the ores of copper. These converters are cylindrical shells, made of boiler plate steel, about 4 feet in diameter and 10 feet high. These shells are mounted on a trunnion, with a tilting device for emptying the charge. Air is blown thru the melting ore at a pressure of 14 pounds to the square inch. The condition of the ore is judged by the color of the flames issuing from the top of the converter. Fifteen tons of ore can be converted to a metallic state in about one hour. The resulting copper is known as blister copper, and is used as "anodes" for the electrolytic method.

When especially pure copper is desired, or when the ore is known to contain a considerable percentage of gold and silver (which is often the case), the electrolytic method is used. This method consists of attaching a thick plate of "blister" copper (called the "anode"), weighing about 200 pounds, to the positive pole of a dynamo, and a thin sheet of copper, called the "cathode," to the negative pole. These plates are immersed in an acid solution, and an electric current is passed from the "anode" thru the solution to the "cathode." This results in the dissolving of the anode, which is deposited upon the cathode, the gold and silver and other impurities falling to the bottom of the solution. The copper deposited upon the cathode is pure copper and the precious metals at the bottom of the solution are recovered by the use of precipitants and mercury. The metals that are precipitated to the bottom of the solution usually consist of about 40 per cent silver, 25 per cent copper, 2 per cent gold, 10 per cent arsenic, the balance consisting of lead and other impurities.

The acid solution used in this process consists of: sulphuric acid, 10 per cent; bluestone, 15 per cent; water, 75 per cent, and a very small percentage of sodium chloride for the purpose of precipitating the silver. The solution is contained in large wooden tanks lined inside with lead and painted with tar.

Electrolytic refining costs about $12.00 per ton, and the bulk of the world's copper is treated by this method. The copper thus produced averages 99.93 per cent pure; it is also the best conductor of electricity, indicating a conductivity of 104 per cent.

V. COMMERCIAL FORMS OF COPPER

In the United States copper is usually roughly divided into three grades: Lake copper, that which is obtained from the mines of the Lake Superior region; electrolytic copper, that which has been refined by the electrolytic process; casting copper, that which is not entirely refined, but carries varying amounts of impurities. This last named grade of copper is disappearing from the market because of the development of scientific alloying where the composition of the metals used must be definitely known.

The specific gravity of copper is 8.82, its melting point 1,981 degrees Fahrenheit. Its tensile strength varies with its physical condition, but is as follows: in cast copper, 26,000 pounds per square inch; wire, 55,000 pounds per square inch.

It is the best conductor of both heat and electricity, slightly excelling even silver in the latter respect. Chemically pure silver was for years believed to have the highest electrical conductivity of all the metals, and accordingly the basis for the 100 per cent standard. Recently, however, copper has been produced with such a high degree of purity as to indicate an electrical conductivity of 104 per cent.

Copper is very malleable and ductile and may be drawn into very fine wire or rolled into thin foil one two-hundredth of an inch thick. It becomes harder as it is worked, but by heating to 608 degrees Fahrenheit it regains its malleability. It may be thrown into water while red hot and cooled quickly or it may be allowed to cool slowly in the air and it will be equally soft in either case.

Copper or brass in sheets, bars, rods, or in the form of wire, tube, rivets, etc., can readily be obtained from any of the manufacturers whose addresses are given in Chapter VII.

For many years there has been a popular belief, current even at the present time, that the ancient Egyptians, the North American Indians, the mound-builders, and the cliff dwellers possessed the secret of hardening and tempering copper, and many a poor deluded enthusiast has spent time and money in an endeavor to rediscover the supposed secret, and thereby win for himself the fabulous reward that was supposedly awaiting the discoverer. While it is perfectly true that many of the copper articles that have been found in various parts of the world are harder than is usual in copper, it has been proven that the hardness was caused by the accidental addition of a small quantity of some other metal such as nickel, tin, etc. In many cases the ore itself contained enough of the foreign metal to give the hardness noticed. With the modern methods of scientific alloying it is now possible to produce a copper alloy that is harder by far than any piece made by the ancients.

The commonest forms in which copper is placed upon the market are as follows:

Ingots, of about 60 pounds in weight, with two deep depressions so that they can the more readily be cut into three parts for convenient handling in melting and casting.

"Wire bars," about three and one-half inches square and five feet long, averaging in weight about 350 pounds. These are used for drawing down into wire of various shapes and sizes.

Copper for rolling into sheets is placed on the market in the form of square cakes weighing from 100 to 1,000 pounds.

Anodes of impure copper to be refined by the electrolytic process. These usually weigh about 200 pounds each.

Cathodes of pure copper, weighing the same as the anodes. These are the product of the electrolytic process, and are bought by manufacturers to roll into sheets.

Sheet copper of varying grades and thickness. These sheets are generally 30 inches wide and 60 inches long. It is cheaper to buy an entire sheet, as the dealers charge considerable for cutting into a sheet. The sheets are sometimes designated and sold by weight. A 30 by 60 sheet, which is 18-gage, Brown-Sharpe gage, weighs about 20 pounds, and is called a 20 lb. sheet.

There are two methods of rolling copper into sheets, the straight rolling system and the "Welsh" cross rolling system. The straight rolling system consists in rolling a plate of copper between hardened steel rolls to about 0.25 or 0.75 inch thick, cutting it to the proper weight for the desired gage of sheet, then heating and rolling in packs on finishing rolls to the desired length.

Hot rolled copper is not as smooth or tough as cold rolled copper, so if possible order direct from the wholesalers and specify cold rolled and annealed copper as it is smoother, tougher, and more elastic.

The Welsh cross rolling system is much slower and more expensive and is being superseded by the straight rolling. Cross rolling is done by rolling cake copper to about 25 inches wide and about one-quarter inch thick, cutting to the desired weight and rolling crosswise to the desired width.

CHAPTER IV.

ALLOYS OF COPPER.

An alloy is a combination of two or more metals mixed together in varying proportions while melted. Alloys of various metals may be formed that have certain desirable qualities possessed by none of the metals separately. The alloying of metals is of great value to the commercial and the scientific world, because by scientific alloying metals can be produced that have certain special properties for special uses; for instance, in the manufacture of automobiles, aeroplanes, electrical machinery, and scientific instruments metals are needed that possess a certain known degree of density, tenacity, hardness, color, malleability, or fusibility; or it may be that a metal of light weight or low cost is needed in the manufacture of some special machine. Scientific alloying will within a certain range produce metals with any reasonable requirement. As a simple illustration of the principle of alloying, if we melt together two parts of copper and one part of tin, the resulting alloy will be a metal that is of a yellowish gray color, more dense, and much harder than either of the metals of which it was made. The melting point of an alloy is, as a rule, lower than that of either of the metals of which it is composed.

Copper is probably the most used of all metals in the making of alloys. In bronze and brass alloys, copper is the preponderant metal, it being the metal with which we can best alloy smaller quantities of other metals. The principal function of copper in alloys is to impart strength and toughness. In ornamental work it imparts varying degrees of its red color.

BRASS

Brass, the most common and useful of the alloys, is a combination of copper and zinc in varying proportions.

High brass consists of copper 65 per cent, and zinc 35 per cent. It is called high brass because its percentage of zinc is high. This is the best brass for etching.

Low brass contains 85 per cent of copper, and 15 per cent of zinc.

Tough brass consists of copper 55 per cent, zinc 44 per cent, tin one-half of one per cent, aluminum one-half of one per cent.

Red brass contains copper 85 per cent, tin 6 per cent, zinc 5 per cent, lead 4 per cent.

Yellow brass contains copper 67 per cent, zinc 31 per cent, lead 2 per cent.

Bearing brass, used especially for bearings on machinery, is a very hard alloy composed of copper 82 per cent, tin 14 per cent, zinc 4 per cent.

The standard automobile bearing alloy used by practically all of the prominent manufacturers is composed of copper 80 per cent, tin 10 per cent, lead 10 per cent.

The last two alloys given, altho they are called brass, are in reality bronze, the distinction being that in alloys of copper where the secondary metal is zinc, the alloy is known as brass. The alloy in which the secondary metal is tin is known as bronze.

Bronze bells are made of copper 75 per cent, tin 25 per cent.

Phosphor bronze, used extensively in boat building, is composed of copper 80 per cent, tin 15 per cent, zinc 5 per cent. When it is being melted a flux of phosphorus is used.

Monument bronze is composed of copper 87 per cent, tin 7 per cent, lead 3 per cent, zinc 3 per cent.

OTHER ALLOYS

A few of the most useful and well known copper alloys are:

Aluminum bronze, copper 90 per cent, aluminum 10 per cent.

German Silver, copper 62 per cent, zinc 20 per cent, nickel 18 per cent.

Babbit metal, copper 10 per cent, antimony 22 per cent, tin 68 per cent.

Brittania metal, tin 90 per cent, antimony 8 per cent, copper 2 per cent.

Dentists' alloy, used for filling teeth, silver 50 per cent, tin 45 per cent, copper 5 per cent.

Muntz metal, copper 60 per cent, zinc 40 per cent.

There are many various agencies that are endeavoring to standardize the alloys for certain specific uses, the most prominent of these being the United States government and the different engineering societies. The Society of Automobile Engineers has adopted the following alloys as standard in the manufacture of automobiles: *Hard bronze,* 87 to 88 per cent copper, 9.5 to 10.5 per cent tin, and 1.5 to 2.5 per cent zinc; *Gear bronze,* 88 to 89 per cent copper, 11 to 12 per cent tin, 0.15 to 0.30 per cent phosphorus. The hard bronze is identical with the United States government specifications, and is offered as a general utility bronze for use under severe working conditions of heavy pressure and high speed. The gear bronze is known in the trade as English gear bronze and is especially useful where high speed and quiet running are necessary.

Chapter V.

METAL GAGES.

The thickness of sheet metals is measured by a small instrument called a gage. It is a flat circular disk of hardened steel with slots in the edge, Fig. 1. The slots are numbered, the smallest one into which the edge of the sheet metal slips easily is said to be the gage of the metal in thickness.

In the United States we have unfortunately adopted a system of using different gages for different metals, or for various groups of metals. We even go so far in some cases as to use different gages for the same metal in different trades, which sometimes causes annoying complications. For example, plumbers and coppersmiths measure their copper, brass, zinc, etc., with the Stubs gage, while silversmiths, goldsmiths, and art metalworkers measure the same metals with the Brown and Sharpe gage (so called after the famous machine manufacturers of Providence, Rhode Island). Art metalworkers when measuring or when ordering metals should always use and specify the Brown and Sharpe gage.

Table I shows the differences between the various gages used in this country. Table II shows the weights per square foot of copper and brass of the most common gages of metals as measured by the Brown and Sharpe gage. Table III shows the weights of the same metals as measured by the Stubs gage. Table IV shows the weights per lineal foot of solid, round, and square brass and copper rods.

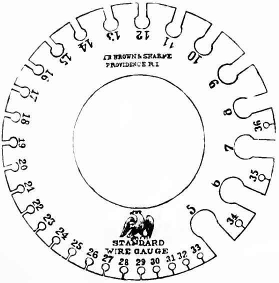

Fig. 1. Brown & Sharpe's American or new gage.

Table Showing the Differences Between Standard Wire Gages.

No. of Gage	American or Brown & Sharpe	Birmingham or Stubbs	New British	Old English or London	Washburn & Moen	United States Standard	No. of Gage
5-0	....	....	.432	....	.430	.4375	5-0
4-0	.460	.454	.400	.454	.393	.40625	4-0
3-0	.40964	.425	.372	.425	.362	.375	3-0
2-0	.36480	.380	.348	.380	.331	.34375	2-0
0	.32486	.340	.324	.340	.307	.3125	0
1	.28930	.300	.300	.300	.283	.28125	1
2	.25763	.284	.276	.284	.263	.265625	2
3	.22942	.259	.252	.259	.244	.25	3
4	.20431	.238	.232	.238	.225	.234375	4
5	.18194	.220	.212	.220	.207	.21875	5
6	.16202	.203	.192	.203	.192	.203125	6
7	.14428	.180	.176	.180	.177	.1875	7
8	.12849	.165	.160	.165	.162	.171875	8
9	.11443	.148	.144	.148	.148	.15625	9
10	.10189	.134	.128	.134	.135	.140625	10
11	.09074	.120	.116	.120	.120	.125	11
12	.08081	.109	.104	.109	.105	.109375	12
13	.07196	.095	.092	.095	.092	.09375	13
14	.06408	.083	.080	.083	.080	.078125	14
15	.05706	.072	.072	.072	.072	.0703125	15
16	.05082	.065	.064	.065	.063	.0625	16
17	.04525	.058	.056	.058	.054	.05625	17
18	.04030	.049	.048	.049	.047	.05	18
19	.03589	.042	.040	.040	.041	.04375	19
20	.03196	.035	.036	.035	.035	.0375	20
21	.02846	.032	.032	.0315	.032	.034375	21
22	.025347	.028	.028	.0295	.028	.03125	22
23	.022571	.025	.024	.027	.025	.028125	23
24	.0201	.022	.022	.025	.023	.025	24
25	.0179	.020	.020	.023	.020	.021875	25
26	.01594	.018	.018	.0205	.018	.01875	26
27	.014195	.016	.0164	.01875	.017	.0171875	27
28	.012641	.014	.0148	.0165	.016	.015625	28
29	.011257	.013	.0136	.0155	.015	.0140625	29
30	.010025	.012	.0124	.01375	.014	.0125	30
31	.008928	.010	.0116	.01225	.0135	.0109375	31
32	.00795	.009	.0108	.01125	.0130	.01015625	32
33	.00708	.008	.0100	.01025	.0110	.009375	33
34	.0063	.007	.0092	.0095	.0100	.00859375	34
35	.00561	.005	.0084	.009	.0095	.0078125	35
36	.005	.004	.0076	.0075	.0090	.00703125	36
37	.00445	....	.0068	.0065	.0085	.006640625	37
38	.003965	....	.0060	.00575	.0080	.00625	38
39	.003531	....	.0052	.005	.0075	....	39
40	.003144	....	.0048	.0045	.0070	....	40

Table I.

TABLE OF WEIGHTS PER SQUARE FOOT OF

COPPER AND BRASS SHEETS.

AMERICAN, OR B. & S. GAGE		COPPER	BRASS
No.	Thickness.	Lbs.	Lbs.
0000	.46 in., or 7-16 in. full	20.838	19.688
000	.40964 in.	18.557	17.533
00	.3648 " or 3/8 in. scant	16.525	15.613
0	.32486 "	14.716	13.904
1	.2893 "	13.105	12.382
2	.25763 " or 1/4 in. full	11.670	11.027
3	.22942 "	10.392	9.819
4	.20431 "	9.255	8.745
5	.18194 " or 3-16 in. scant	8.242	7.788
6	.16202 "	7.340	6.935
7	.14428 "	6.536	6.175
8	.12849 " or 1/8 in. full	5.821	5.499
9	.11443 "	5.183	4.898
10	.10189 "	4.616	4.361
11	.090742"	4.110	3.884
12	.0808 "	3.66	3.457
13	.0720 "	3.26	3.08
14	.06408 "	2.90	2.743
15	.057068"	2.585	2.442
16	.05082 "	2.302	2.175
17	.045257"	2.05	1.937
18	.0403 "	1.825	1.725
19	.0359 "	1.626	1.536
20	.0320 "	1.448	1.367
21	.02846 "	1.289	1.218
22	.02535 "	1.148	1.085
23	.02257 "	1.023	.966
24	.0211 "	.910	.860
25	.0179 "	.811	.766
26	.0159 "	.722	.682
27	.01419 "	.643	.608
28	.01264 "	.573	.541
29	.01126 "	.510	.482
30	.01003 "	.454	.429
31	.0089 "	.404	.382
32	.0079 "	.360	.340
33	.0071 "	.321	.303
34	.0063 "	.286	.269
35	.0056 "	.254	.240
36	.0050 "	.226	.214
37	.00445 "	.202	.191
38	.00396 "	.180	.170
39	.00353 "	.160	.151
40	.00314 "	.142	.135

Table 11

TABLE OF WEIGHTS PER SQUARE FOOT OF
COPPER AND BRASS SHEETS.

	STUBS' GAG	COPPER	BRASS
No.	Thickness	Lbs.	Lbs.
0000	.464 in. or 7-16 in. full	20.556	19.431
000	.425 "	19.253	18.19
00	.380 " or 3/8 in. full	17.214	16.264
0	.340 " " 11-32 in. scant	15.402	14.552
1	.300 " " 19-64 " full	13.59	12.84
2	.284 " " 9-32 " "	12.865	12.155
3	.259 " " 1/4 " "	11.733	11.09
4	.238 " " 15-64 " "	10.781	10.19
5	.220 " " 7-32 " "	9.966	9.416
6	.203 " " 13-64 " "	9.20	8.689
7	.180 " " 3-16 " scant	8.154	7.704
8	.165 " " 11-64 " "	7.475	7.062
9	.148 " " 9-64 " full	6.704	6.334
10	.134 " " 9-64 " scant	6.070	5.735
11	.120 " " 1/8 " "	5.436	5.137
12	.109 " " 7-64 "	4.938	4.667
13	.095 " " 3-32 " full	4.303	4.066
14	.083 " " 5-64 " "	3.760	3.552
15	.072 " " 5-64 " scant	3.262	3.08
16	.065 " " 1-16 " full	2.945	2.78
17	.058 " " 1-16 " scant	2.627	2.48
18	.049 " " 3-64 " full	2.220	2.10
19	.042 " " 3-64 " scant	1.90	1.80
20	.035 " " 1-32 " full	1.59	1.50
21	.032 " " 1-32 " scant	1.45	1.37
22	.028 "	1.27	1.20
23	.025 "	1.13	1.07
24	.022 "	.997	.941
25	.020 "	.906	.856
26	.018 "	.815	.770
27	.016 " or 1-64 in.	.725	.685
28	.014 "	.634	.599
29	.013 "	.589	.556
30	.012 "	.544	.514
31	.010 "	.453	.428
32	.009 "	.408	.385
33	.008 "	.362	.342
34	.007 "	.317	.2996
35	.005 "	.227	.214
36	.004 "	.181	.171

Table III.

TABLE OF WEIGHTS PER LINEAL FOOT OF BRASS AND COPPER ROD.

	BRASS.		COPPER.	
INCHES.	ROUND.	SQUARE.	ROUND.	SQUARE.
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*
1-16	.011	.014	.01155	.0147
⅛	.045	.055	.047	.060
3-16	.100	.125	.106	.13497
¼	.175	.225	.189	.241
5-16	.275	.350	.296	.377
⅜	.395	.510	.426	.542
7 16	.540	.690	.579	.737
½	.710	.905	.757	.964
9-16	.90	1.15	.958	1.22
⅝	1.10	1.40	1.182	1.51
11-16	1.35	1.72	1.431	1.82
¾	1.66	2.05	1.703	2.17
13-16	1.85	2.40	1.998	2.54
⅞	2.15	2.75	2.318	2.95
15-16	2.48	3.15	2.660	3.39
1	2.85	3.65	3.03	3.86
1 1-16	3.20	4.08	3.42	4.35
1 ⅛	3.57	4.55	3.831	4.88
1 3-16	3.97	5.08	4.269	5.44
1 ¼	4 41	5.65	4.723	6.01
1 5-16	4.86	6.22	5.21	6.63
1⅜	5.35	6.81	5.723	7.24
1 7-16	5.85	7.45	6.255	7.97
1½	6.37	8.13	6.811	8.67
1 9-16	6.92	8.83	7.39	9.41
1⅝	7.48	9.55	7.993	10.18
1 11-16	8.05	10.27	8.45	10.73
1¾	8.65	11.00	9.27	11.80
1 13-16	9.29	11.82	9.76	12.43
1⅞	9.95	12.68	10.642	13.55
1 15-16	10.58	13.50	11.11	14.15
2	11.25	14.35	12.108	15.42
2⅛	12.78	16.27	13.668	17.42
2¼	14.32	18.24	15.325	19.51
2⅜	15.96	20.32	17.075	21.74
2½	17.68	22.53	18.916	24.09
2⅝	19.50	24.83	20.856	26.56
2¾	21.40	27.25	22.891	29.05
2⅞	23.39	29.78	25.019	31.86
3	25.47	32.43	27.243	34.69
3¼	30.45	38.77	31.972	40.71
3½	35.31	44.96	37.081	47.22
4	46.124	58.73	48.433	61.67

To find the weight of Octagon Rod, take the weight of Round Rod of a given size and multiply by 1,084.

To find the weight of Hexagon Rod, take the weight of Round Rod of a given size and multiply by 1.12

Table IV.

Chapter VI.

COLORING AND FINISHING ART METALWORK.

The coloring and finishing of art metalwork is a very important factor in its success whether viewed from a commercial, artistic, or educational standpoint. It is of importance commercially because articles well colored and finished will sell more readily than those that are not. It is of importance artistically because of the color harmonies and tone values that are involved. It is of importance educationally because of the direct correlation with an important school and industrial subject, namely, chemistry.

Copper has an especially strong affinity for sulphur and oxygen. It combines readily with the moisture and carbon dioxide of the atmosphere to form basic copper carbonate and basic copper chloride. There is no other metal known upon which so many, or so beautiful colors can be produced readily and easily by means of its own compounds. If a piece of copper is cleaned and exposed to the air for a few weeks, it will assume a dark color (frequently called the "Patina") caused by its combination with the oxygen of the air, or with the hydrogen sulphide if soft coal is burned in the neighborhood, or it will turn a green color caused by its combination with the moisture and the carbon dioxide present in the air.

There are three important points to keep in mind when coloring and finishing art metalwork: *first,* the work must be perfectly clean; *second,* all of the chemical solutions when not being used must be kept in well corked bottles; *third,* no matter what color is obtained the final operation must be to protect and preserve the color by a coat of lacquer or wax.

To color successfully art metalwork, whether copper, brass, silver, or gold, one must always keep in mind that the metal must be perfectly clean and free from any trace of oil or grease. Even so slight a thing as the moisture from the hands is a frequent cause of failure along this line. The metal may be cleaned by friction, that is, by rubbing with emery cloth, powdered pumice, or a wire brush, or polishing on a lathe; or it may be cleaned by dipping for a few seconds in strong acids.

THE BRIGHT DIPS

When using the "acid dip" method on copper and brass the work must be fastened to a piece of copper or brass wire (do not use iron wire), and hung in the solution for about five to thirty seconds, the length of time depending upon the strength of the solution. The work must then be thoroly washed off in cold running water. Care must be taken to avoid getting any of the solution upon the hands or clothing. A few of the best of these dipping solutions are as follows:

No. 1. Sulphuric acid, one part.
Nitric acid, one part.

No. 2. Sulphuric acid, one part.
Nitre, one part,
Water, one part.

No. 3. Yellow aqua fortis, 1 quart,
Sulphuric acid, 1 quart,
Muriatic acid, 1 gill,
Water, 1 pint.

No. 4. Sulphuric acid, 1 quart,
Nitric acid, 1 pint.

No. 5. Hydrofluoric acid, 4 quarts,
Nitric acid, 3 quarts,
Common salt, 2 tablespoonfuls.

THE SATIN DIPS

Beside these so called "bright dips" there is another class of dips that are handled in the same way, but give a slightly different result. These are called "satin dips." They are very similar to the bright dips, but in addition they give the work a slightly granulated effect that is known as satin finish. This satin finish may also be obtained by the use of a satin finish wire brush on a lathe revolving at high speed. Some of the acid satin finish dips are are as follows:

No. 1. Hydrofluoric acid, 1 pint,
Water, 3 pints.

No. 2. Hydrofluoric acid, 2 pints,
Nitric acid, 1 pint,
Muriatic acid, one-half pint,
Water, 5 pints.

No. 3. Hydrofluoric acid, 1 pint,
Nitric acid, one-half pint,
Water, 5 pints.

No. 4. Hydrochloric acid, 1 pint,
Sulphuric acid, 6 pints,
Water, 6 pints.

Immerse the brass in the solution for about ½ hour.

THE ORMOLU DIP

There is still one other acid dip that is very useful when finishing art metalwork, the "ormolu dip." This dip gives to brass a golden yellow color, and is commonly used on commercial goods to imitate gold finishes. It is prepared as follows:

No. 1. Nitric acid, 2 pints,
Hydrofluoric acid, 2 pints,
Zinc scraps, 2 ounces.

No. 2. Sulphuric acid, 2 quarts,
Water, one-fourth pint,
Nitre, 3 pounds,
Add slowly to above solution
Muriatic acid, 1 quart.

As hydrofluoric acid will dissolve glass or crockery, any solution that has hydrofluoric acid in it should be kept in a jar that has been painted thoroly on the inside with Sapolin or asphaltum varnish.

After any one of the preceding bright satin or ormolu dips has been used on art metalwork, the work should be immediately dried and lacquered by dipping in banana oil, or it should be warmed and coated with a thin coating of Johnson's black furniture wax, and then lightly polished with a soft cloth when it is cold.

COLORING SOLUTIONS

There are many recipes for obtaining various color effects upon copper, some of which are expensive and difficult to handle. and others require considerable skill in their application. Some of the standard and easily applied (simple immersion) coloring solutions for use on copper are as follows:

No. 1. Antique or Oxidized Copper. Dissolve about one cubic inch of potassium sulphide in one pint of water, add six drops of ammonia, and apply to the copper; if the color is too dark add more water. When it is dry, polish with emery cloth in one direction only to relieve the color and bring out the design; then lacquer or wax.

No. 2. Another antique finish on copper that gives a more varigated color effect is as follows: In one pint of water dissolve one-fourth of a teaspoonful of barium sulphide. Clean the article thoroly and wash in cold water; while it is still wet apply the barium sulphide solution. Various results can be obtained by making the solution weaker or stronger. When it is dry finish by lacquering or waxing.

No. 3. Brown color on copper, shading to black according to strength of solution: in one pint of water dissolve five drachms of nitrate of iron.

No. 4. Potassium sulphide, three ounces; ammonia, one-half ounce; water, one gallon. Immerse the articles.

No. 5. Dark brown on copper: one pint of water, five drachms of nitrate of iron, and two drachms of potassium sulphocyanide.

No. 6. Brown on copper: dissolve one ounce of sal ammoniac and one-third of an ounce of oxalate of potash in one-half pint of vinegar. Immerse and apply with a cloth.

No. 7. Dark brown: in one pint of water dissolve one ounce of sulphate of copper, one ounce of hyposulphate of soda, two drachms of hydrochloric acid.

No. 8. Red shading to brown, according to strength of solution: in one pint of water dissolve one drachm of pearl ash, and one drachm of sulphur.

No. 9. Red: one pint of water, two drachms of sulphide of arsenic, one ounce of pearl ash.

No. 10. Steel gray: in one pint of water dissolve one drachm of chloride of arsenic. Bring the solution nearly to the boiling point and immerse the articles in it.

No. 11. Various colors may be obtained by means of the following solution: dissolve in one quart of water three hundred grains of acetate of lead, and six hundred grains of hyposulphite of soda. After the solution is dissolved, heat to the boiling point and immerse the articles. The first color produced is gray, continued baths will produce violet, maroon, red, and finally steel blue.

No. 12. There is also the very interesting method of coloring copper by heat. In this method no chemicals of any kind are used; all that is necessary is that the metal shall be perfectly clean and that it be slowly passed to and fro thru a blue gas flame, such as is obtained from a bunsen burner or any ordinary gas stove. It is also possible to get results from other heating methods such as a clear hard coal fire, but the trouble with such methods is that the article is very liable to get smoked. The colors obtained by the heat method come in this order if it is done slowly: *First,* orange red; *Second,* bluish purple; *Third,* brassy color; *Fourth,* dark red; *Fifth,* deep purple; *Sixth,* iridescent; *Seventh,* chestnut color. The first two colors partially come off when the lacquer or wax is applied. All the others are permanent if they are lacquered or waxed. The lacquer is applied as soon as the article is cold, the wax while it is still warm. Care must be taken when obtaining the chestnut color not to pass it into the flame any more when the chestnut color begins to come, because if the chestnut color is carried too far the color will flake off and the entire process of cleaning and coloring will have to be repeated.

No. 13. For a dead black finish on copper immerse in this solution: water, five quarts; one-fourth pound sulphate of potassium; two ounces of concentrated spirits of sal ammoniac.

No. 14. A steel gray dipping solution for copper is as follows: dissolve four ounces of muriate of arsenic in two quarts water. Use hot.

APPLYING SILVER SOLUTIONS

There are also some interesting methods of applying a thin coat of silver to copper articles, and while this method is not recommended for very extensive use, still some very good effects can be produced by applying the silvering solution to the copper where a design has been etched or chased and then rubbing with an old smooth piece of emery cloth, allowing the silver to remain in the background. The copper must, of course, be perfectly clean.

No. 1. With a little water make a paste of nitrate of silver 80 grains, common salt 40 grains, cream of tartar 7 drachms, and rub on to the copper.

No. 2. Another silvering paste is made of chloride of silver, 4 ounces; cream of tartar, 75 ounces; common salt, 10 ounces, and water sufficient to form a paste. Keep this paste away from the light, and apply by rubbing on the copper with a piece of cloth.

No. 3. A good silvering fluid is composed of distilled water, 5 ounces; chloride of silver, 7 ounces; potassic oxalate, 10 ounces; common salt, 30 ounces; chloride of ammonia, 4 ounces. Mix together and apply by rubbing on the metal with a piece of soft cloth.

No. 4. Another simple method of silvering copper and brass is to put one ounce of aquafortis and one ounce of silver scraps in a crockery dish and set it in a warm place until the silver is entirely dissolved. Then mix with it enough cream of tartar to make a thin paste. This paste will silver copper or brass when rubbed on with a soft cloth.

GILDING AND BRONZING

Copper and brass can be gilded by using the following solution: distilled water, 1 quart; 6 pennyweights of gold converted into chloride, potassium bicarbonate, 16 ounces. To prepare this solution for use, convert the gold into chloride by dissolving it in aqua regia.[2] Then dissolve in the distilled water, add the potassium bicarbonate, and allow the solution to simmer over a fire for about one hour. The articles to be gilded are immersed in the warm fluid for a few seconds until the desired color is obtained.

Another good recipe for gilding by boiling is cyanide of potassium, 8 ounces; chloride of gold, 3 pints; sal soda, 8 ounces; water, 1 gallon.

To get a bronze effect on copper, dissolve 3 ounces of nitrate of iron and 1 ounce of sulphocyanide of potassium in 2 quarts of water, and immerse the articles.

ANTIQUE FINISHES

Another standard method of finishing copper is to give it any of the many various green finishes that are known on the market and in the trade as "Antique Patina," "Verde antique," "Pompei Green," "Green Patina," etc. The same finish is often given different names by different manufacturers. Some of the most reliable of these finishes are as follows:

No. 1. Copper nitrate, 16 grains; ammonium chloride, 16 grains; calcium chloride, 16 grains; water, 1 ounce. Brush the solution on the article with a stiff brush and allow it to dry; if necessary apply a second time, then relieve with emery cloth, and lacquer or wax.

No. 2. To obtain a green color on either copper or brass: ammonia muriate, 1 ounce; ammonia carbonate, 3 ounces; water, 24 ounces.

No. 3. A popular so-called verde antique finish on copper and brass is produced by the use of this formula: common salt, 4 ounces; chloride of iron crystals, 1 ounce; verdigris, 3 ounces;

[2] Aqua regia is equal parts of nitric acid and muriatic acid mixed together; it is the only solution that will dissolve gold.

sal ammoniac, 5 ounces; cream of tartar, 2 ounces; water, 1 pint. Immerse the work in the solution and allow to dry.

No. 4. For a yellowish green on copper use the following: copper nitrate, 1 ounce; sal ammoniac, 1 ounce; chloride of calcium, 1 ounce; water, 2 quarts. Apply with a stiff brush and allow to dry.

No. 5. For an olive green color on copper and brass: one part of perchloride of iron and two parts of water mixed together will give copper or brass a pale or deep olive green, according to the time that the work is left in the solution. The work must be immersed and then allowed to dry.

No. 6. Another green solution is composed of nitrate of iron, 2 ounces; hyposulphite of soda; water, 1 pint.

No. 7. A good antique green can be obtained by using the following solution: 1 part sal ammoniac, 3 parts cream of tartar, 3 parts common salt, 12 parts boiling water, 8 parts cupric nitrate. Apply with a brush and allow to dry.

No. 8. If copper or brass is dipped in acetic acid and then exposed to the fumes of ammonia for a few hours the metal will acquire a mixture of black, blue, and green colors.

No. 9. Olive green on copper: 2 parts water, 1 part permuriate of iron.

No. 10. A recipe for green coloring that is good on copper, brass, or bronze is as follows: sal ammoniac, 5 parts; acetic acid, 10 parts; common salt, 1 part; cream of tartar, 1 part; acetate of copper, 1 part; water, 1 part. Mix thoroly and apply with stiff brush.

FINISHES FOR BRASS ONLY

The foregoing recipes are for copper and brass where so stated and the following are for brass only:

No. 1. To obtain a dark antique finish on brass apply butter of antimony to the brass and allow it to dry.

No. 2. A steel blue color can be produced on brass by immersing in the following solution: sodium hyposulphite, 4 ounces; acetate of lead, 2 ounces; water, 2 quarts. This solution is used hot. Various colors can be obtained by varying the degree of heat and the time of immersion.

No. 3. To dull brass apply with a brush the following solution: 12 parts hydrochloric acid, 1 part ferric oxide. Apply with a brush.

No. 4. A slightly different result may be obtained by adding to the above recipe one part of white arsenic.

No. 5. A solution for coloring brass steel gray: dissolve 4 ounces of muriate of arsenic in 2 quarts of water and immerse the articles.

No. 6. The so-called Flemish gray on brass is obtained by dipping in the following solution: muriatic acid, ½ ounce; white arsenic, ¼ ounce; potassium sulphuret, 6 grains; water, 2 gallons. Mix the arsenic in the acid, add the water, then the potassium.

No. 7. Brown to red shades for brass: dissolve 8 ounces nitrate of iron and 8 ounces of hyposulphite of soda in 2 quarts of water.

No. 8. Black to brown shades for brass: dissolve 3 ounces nitrate of iron and 2 ounces perchloride of iron in 3 quarts of water.

No. 9. For a golden bronze color on brass: dissolve 3 pounds nitrate of potash in 2 quarts of sulphuric acid, then add 2 gills of nitric acid and 2 gills of hydrochloric acid.

No. 10. For a bright green: dissolve ½ pound sal ammoniac and ½ pound sulphate of copper in 2 quarts of boiling water. Apply with a stiff brush and allow to dry.

No. 11. A duller green can be produced by dissolving 4 ounces sulphate of copper in 2 quarts of boiling water. Immerse the articles and allow them to dry.

No. 12. Still another method is to immerse the articles in a hot solution consisting of hyposulphite of soda, 4 ounces; nickel salts, 4 ounces; water, 2 quarts. After immersion in the solution dip the articles in clean boiling water.

No. 13. There is one very interesting method of coloring brass that has no distinctive name, and that is to copper plate the brass and then to polish off the copper plate on the high spots leaving the copper plate in the background, and then to lacquer the work. This makes a very effective finish and is one that is not commonly known. The method is as follows: mix together ½ pint sulphuric acid and 2 pints of water; add 1 tablespoonful sulphate of copper crystals. After the piece of brass work has been thoroly cleaned, wind around it a piece of thin iron wire or a narrow strip of sheet iron, and place in the solution for about 15 minutes. This will copper plate the article. Dry with a cloth, polish all in one direction with a piece of smooth emery cloth, and lacquer and wax. If the solution gets worn out put in more sulphate of copper. There is an interesting chemical fact in connection with this kind of copper plating, and that is that the sulphate of copper is simply copper in another form, suspended in the solution, but the iron displaces or precipitates it and deposits it on the copper, or upon any piece of iron that is held in the solution. This is a practical application of the "electromotive series" of chemistry.

FINISHES FOR SILVER

To oxidize silver any of the following may be used:

No. 1. Dissolve in 1 pint of water 1 cubic inch of sulphide of potassium, and apply to the silver.

No. 2. Slightly warm the silver article and apply hyposulphuret of ammonium.

No. 3. Dissolve a pinch of chloride of platinum in a cupful of warm water and apply to the silver. The disadvantage of this recipe is that any platinum compound is very expensive.

No. 4. Place the silver in a small closed box with a piece of sulphide of potassium.

No. 5. Dissolve a pinch of barium sulphide in a cupful of warm water. Apply to the silver.

No. 6. Dissolve a pinch of ammonium sulphide in a cupful of warm water, and apply to the silver.

When using any of the above solutions to color silver, if the color is not dark enough add more of the chemical and if it is too dark weaken by adding water. To clean silver that is tarnished dip in a solution of 1½ pounds of cyanide of potassium dissolved in 1 gallon of water.

Aluminum can be cleaned by immersing in a solution of caustic soda. To frost aluminum dissolve 2 ounces of caustic soda in 1 pint of water. A formula for blackening or oxidizing aluminum is as follows: chloride of zinc, 1 pound; sulphate of copper, 1 ounce; hot water, 2 quarts. Dip the articles in the solution. If the metal does not turn black fast enough, add a little more sulphate of copper.

As a last word of advice on the coloring of any metal, be sure that the chemicals are fresh, as almost all of the chemicals used in coloring deteriorate with age or exposure to the air.

LACQUERING AND WAXING

Lacquer serves on metal the same purpose that varnish does on wood; that is, preserves the color and the finish. The commercial lacquers are rather expensive and are not always easy to obtain.

No. 1. Banana oil, sometimes called bronzing liquid, makes a fairly good lacquer for our purpose, and it has the decided advantage of being obtainable in almost any drug store.

No. 2. A fair lacquer can be made from white shellac and grain alcohol mixed together in the proportion of 5 ounces of white shellac to 2 quarts of grain alcohol. Allow the mixture to stand for about 48 hours, then strain thru a double thickness of cheese cloth, and it is ready for use.

No. 3. Another lacquer is made up of the following: alcohol, 2 quarts; seed-lac, 5 ounces; gum copal, ½ ounce. Allow the mixture to stand, stirring occasionally until the seed-lac and the gum are dissolved, then strain thru cheese cloth.

No. 4. Collodion thinned down with grain alcohol also makes a good lacquer.

No. 5. A gold colored lacquer for brass only is made of the following: spirits of wine, 2 quarts; tumeric, 6 ounces; gamboge, ½ ounce; sandarac resin, 12 ounces; shellac, 4 ounces; turpentine resin, 5 ounces. Allow the ingredients to dissolve and strain.

No. 6. Another good lacquer for brass or copper: 1 part of spirits of wine; mastic resin, 8 ounces; gum camphor, 6 ounces; sandarac resin, 1 pound; white shellac, 1 pound. Allow the mixture to dissolve and strain.

FINISHING WITH WAX

The best method of wax finishing is to heat the article hot enough just to melt the wax as it is applied with a cloth, then lightly and rapidly apply the wax to the metal. Allow it to get perfectly cold, then polish lightly with a soft cloth. The best wax to use is Johnson's black furniture wax, altho a good wax can be made by melting together equal amounts of beeswax and turpentine. Naptha may be used in place of the turpentine.

Metal articles may be refinished by applying a thin coat of any of the above waxes applied cold.

Chapter VII.

SOURCES OF MATERIALS AND EQUIPMENT.

The following is a list of reliable firms that will supply tools, material, and equipment for art metalwork. The numbers of the tools shown in the illustrations are the same as the numbers given in catalogs issued by the following firms:

TOOLS AND EQUIPMENT

Orr and Lockett Hardware Co., 71 Randolph St., Chicago, Ill.
Henry Paulson and Co., 37 South Wabash Ave., Chicago, Ill.
Chandler and Barber, 122 Summer St., Boston, Mass.
T. K. Lewis, 1536 North High St., Columbus, Ohio.
Belcher and Loomis Hardware Co., 91 Weybosset St., Providence, Rhode Island.
Buffalo Dental Mfg. Co., Buffalo, N. Y.
Wm. Dixon Co., 39 John St., New York, N. Y.
American Art and Supply Co., Newark, N. J., and Chicago, Ill.

COPPER, BRASS, AND GERMAN SILVER

Chas. Besley Co., 19 South Clinton St., Chicago, Ill.
H. K. Benson Co., Glen Ridge, New Jersey.
Detroit Copper and Brass Rolling Mills Co., 239 Lake St., Chicago, Ill.
New Haven Copper Co., Seymour, Conn.
Samuel Harris Co., 23 South Clinton St., Chicago, Ill.
Scovill Mfg. Co., 208 Lake St., Chicago, Ill.
Seymour Mfg. Co., Seymour, Conn.
Waterbury Metal Products Co., Waterbury, Conn.
Canadian Seamless Wire Co., 88 Teranley, Toronto, Canada.
Merchant and Evans Co., Philadelphia, Pa.
C. G. Hussy and Co., Pittsburgh, Pa.
Fitz Dana and Brown, 441 Pearl St., New York, N. Y.
American Brass Co., Waterbury, Conn., and Kenosha, Wis.
Bridgeport Brass Co., Bridgeport, Conn.

PIN STEMS, ETC.

T. K. Lewis, 1536 North High St., Columbus, Ohio.
Henry Paulson and Co., 37 South Wabash Ave., Chicago, Ill.

STERLING SILVER AND SILVER SOLDER.

Handy and Harmon, 22 Pine St., New York, N. Y.
Thomas J. Dee and Co., 5 South Wabash Ave., Chicago, Ill.
John J. Jackson and Co., 91 Mechanic St., Newark, N. J.

CHEMICAL SUPPLIES.

F. H. Kalbfleisch and Co., Broadway and 16th St., New York, N. Y.
International Chemical Co., Camden, N. J.
Bennett-O'Connell Co., Chicago, Ill.
Hanson Van Winkle Co., Newark, N. J.
W. W. Wells, Toronto, Canada.
U. S. Chemical Co., Cleveland, Ohio.
Divine Bros. Co., Utica, N. Y.
General Chemical Co., Philadelphia, Pa.
Frederick B. Stevens Co., Detroit, Mich.
S. Obermeyer Co., Cincinnati, Ohio.
Finkell Hackmeister Co., Pittsburgh, Pa.
Henry Heil Chemical Co., South Fourth St., Saint Louis, Mo.
C. H. Sargent Co., West Lake St., Chicago, Ill.
Wm. Zinnser and Co., 195 William St., New York, N. Y.
American Oil and Supply Co., Newark, N. J., and Chicago, Ill.

ENGLISH FIRMS.

C. J. Plucknett and Co., 28 Poland St., London, W.
Amateurs' Supply Co., 63 Stamford Road, Handsworth Staffs.
Calipe Dettmer and Co., 21 Poland St., London, W.
Gawthorp and Sons, 16 Long Acre, London.

COPPER FINISHING WAX.

S. C. Johnson Co., Racine, Wis.

CELLULOID ENAMELS AND BACKGROUND PAINT.

Celluloid Zapon Co., New York, N. Y.

INEXPENSIVE SPECIMENS OF THE VARIOUS METALLIC ORES.

Braun-Knecht-Heimann Co., 584 Mission St., San Francisco, Cal

PART II.

PROBLEMS.

Chapter VIII.

ETCHING, SOFT SOLDERING.

We hear and read a great deal nowadays about the correlation of design with handwork and manual training. We all know and admit that it is necessary and good, but how are we to do it and what materials shall we do it with? We know that in beginning woodwork it is all the student can do to master the tools and processes. Leather work is a subject that does not present enough technical difficulties. Pottery is very good, but how shall we do our firing and glazing unless we have an expensive kiln? And think of the discouragement to pupil and teacher when a prized piece is broken.

So we turn to the working of copper, silver, and brass, which correlates perfectly with design, line, and form, a subject almost inexhaustible in processes and technic; none of its processes is so difficult but that the painstaking student may master them. The element of interest also enters very largely into it by the making of articles for personal use and adornment, for the home, and for the school.

ETCHING.

One of the simplest and most interesting processes in sheet metalworking is that of etching. It requires very simple equipment, and will show to the student the value of careful, painstaking work. Of the many articles that can be made by this process, the making of a watch-fob or bag-tag is chosen for the first description of tools and processes.

The materials and equipment needed are:

1 piece of soft copper or brass 18-gage (Brown-Sharpe gage); a piece 12″ by 12″ costs about 50 cents.

Black asphaltum varnish, 10 cents. If you cannot obtain the varnish, get a small can of Sapolin, commonly called stove-pipe enamel, 15 cents.

Turpentine to thin the varnish, or benzine to thin the Sapolin, 10 cents.

No. 2 water-color brush, 5 cents.

Nitric acid, 10 cents.
1 piece of carbon paper, 5 cents.
1 machinist's ball pein hammer, $3/4$ lb., 60 cents.
Banana oil, 10 cents.
1 can of lye, 5 cents.
Potassium sulphide, 10 cents.
1 pair tinner's shears, 10″ long, $1.00.
1 small chisel, 10 cents.
1 block of wood.
1 shallow dish, to hold acid solution, 10 cents.
Leather for the strap of the fob or tag when finished.

All the necessary tools are shown in Fig. 2, and would cost about $2.00.

Fig. 2. These tools are all that are necessary to make the work shown in the photographs.

Having all our tools and materials, the next thing needed is the design. For the bag-tag, the best design is a simple monogram, similar to those shown in Fig. 3, remembering always to have the initial of the surname the most prominent. For the watch-fob, we may use either the monogram or a conventional spot design similar to those in Figs. 4 and 5, remembering in all cases that in etching it is better when the design is the raised part and the background is eaten away by the acid, also that the edge of the article whatever it may be, should always be left the full thickness of the metal. See Fig. 3.

Next cut off a piece of metal a little larger than the design, and transfer the design to the metal by placing the shiny side of the carbon paper next to the metal and then placing the design over it and tracing the design carefully all over with a hard pencil; then remove the paper and the design will be seen on the metal. If the design does not show clear, as sometimes happens when the

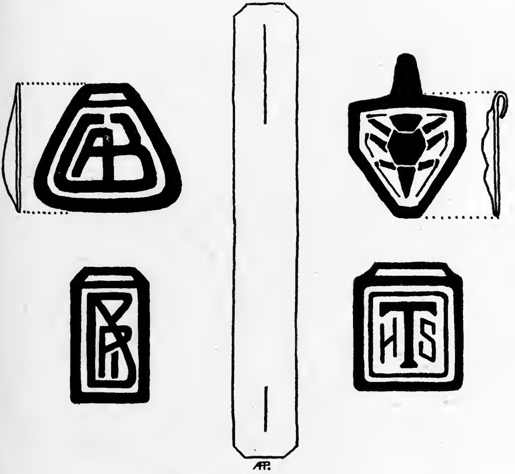

Fig. 3. Designs for bag-tag.

carbon paper is old, warm the carbon paper slightly before using. Now place in a small saucer or butter dish a very little of the sapolin or asphaltum varnish, thinning if necessary with the benzine, naptha, or turpentine, and with the No. 2 water-color brush carefully paint the design, as shown in Fig. 3. Be sure also to paint the back of the fob, remembering that wherever the metal is left bare it will be eaten away by the acid. Now lay aside to dry, which will take from fifteen minutes to two hours, according to the condition of the varnish. The drying of the varnish, however, may be hastened by laying the fob in a warm place.

We have now to prepare the acid solution for the real etching in a rather shallow stoneware or glass dish. Mix the solution of one-third nitric acid and two-thirds water, and when the varnish on the

1 2 3
4 5 6

Fig. 4. Watch-fobs.

fob is dry, place it in the acid solution. If conditions are right, the acid after a few minutes will commence to etch or eat away the metal that has been left bare. This can be told by the very small bubbles rising from the bare metal. If after five minutes' immersion in the solution the bubbles do not rise, pour in a little more acid. Sometimes it happens that the acid is fresh and strong and will etch too fast. This can be told by the large bubbles rising very fast, giving the acid almost the appearance of boiling. It also throws off strong yellow fumes. When this occurs, weaken the acid by pouring in more water.

7 8 9

Fig. 5. Watch-fobs.

After it is etched deep enough, which will take anywhere from thirty minutes to three hours, according to the strength of the acid, take the fob out of the acid and remove the varnish by either scraping it off with a scrap of copper or soak for about half an hour in turpentine, gasoline, or a solution of lye, when it will readily wipe off, and cut off the surplus metal with tinner's shears.

The design now looks flat and uninteresting, so beat up the design from the back by placing the fob face downwards on a block of wood and striking it with the ball end of the hammer. When there is a decided center of interest in the design, as in Nos. 1, 2, 4, 5, 9, Figs. 4 and 5, beat that up higher, making it more prominent. If the hammered effect is desired, hammer the edges and the design with the ball end of the hammer on a ball-shaped piece of iron or on the ball end of another hammer. This also stiffens the metal and makes it hard to bend.

Now we have to deal with the problem of fastening the leather to the fob. There are two ways of doing this, as shown in Nos. 6 and 4, Fig. 4. No. 6 has a piece left on the fob and bent backwards into a hook, as shown in the drawing, then passed thru a small the small chisel on the block of wood and file smooth with the small slit in the leather and hammered flat. The second and best way is shown in No. 4, which is to cut out a small slit in the metal with flat file. An easier but much slower way to get the slit in is this: After the design is etched deep enough, remove from the acid and dry, then paint all over the metal, leaving bare the slit, place back in the acid and let it remain until the acid eats clear thru. There is another method—that of sawing out with a jeweler's saw—but on account of the cost of the tools and breakage of saws, we will not consider that method at the present time.

COLORING AND FINISHING.

After the fob is etched, shaped, hammered, and the slit cut in, we have next to color and finish it. In coloring copper, we can get all the shades of color from light brown to black with a solution of potassium sulphide and water. It is not practical to give exact proportions for this solution, as the sulphide deteriorates with age and exposure to the air. However, the simplest method is the following: In one-half pint of water dissolve a piece of potassium sulphide as large as an ordinary grape. This, when rubbed on the copper, will turn it almost black. If you wish a lighter shade, mix a little of this solution with water, varying the proportions according to the color you wish to get. When it is dry, polish lightly with fine emery cloth, bringing the design out in bright copper color and leaving the background darker, then flow on the fob a thin coating of the banana oil and allow that to dry thoroly, which will take about one hour, and it is ready for the leather strap. If the fob is of brass, use the same method, but instead of potassium sulphide use butter of antimony, full strength. If the fob is of silver, use the potassium sulphide, but do not use the banana oil.

If you wish to color either the brass or copper verde or green, flow on with a brush the following solution:

Copper nitrate	16 grains
Ammonia chloride	16 grains
Calcium chloride	16 grains
Water	1 oz.

Allow to dry and finish as before. A quicker method, altho not quite so good, is to mix verdigris with banana oil to the consistency of cream and apply with a brush. When it is dry, rub the design with a cloth soaked in banana oil, which will relieve and bring out the design. Either metal may also be polished bright and finished with the banana oil. See also chap. VI, in which other finishes are described.

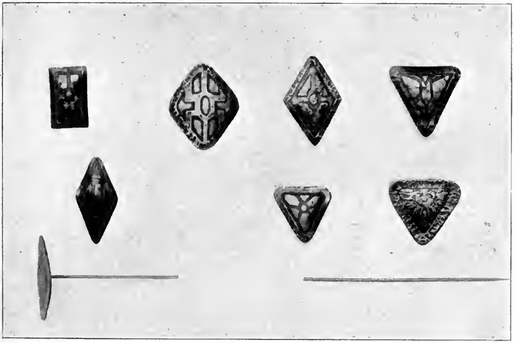

Fig. 6. Hat-pins.

For the leather strap, get a piece of leather 5″ long and as wide as the slit in the fob. Goat or calf skin will do, but if you wish to do the simple tooling such as is shown on No. 2 and No. 3, Fig. 4, you should use Russian calf skin. Then in the end that fastens to the fob cut a slit ½″ long, as shown in the drawing, Fig. 3, and fasten to the fob by the method shown in Nos. 7, 8, 9, Fig. 5. Another way of fastening is shown on No. 1, Fig. 4, which is accomplished as folows: Cut the strip of metal ⅛″ wide and twice as long as the strap is wide. Color and finish the same as the fob and pass the strap thru the slit in the fob. Then bend the

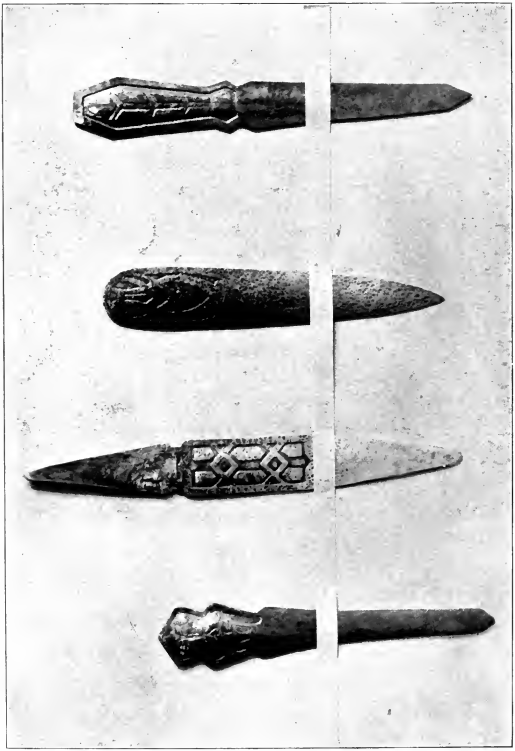

Fig. 7. Paper-knives.

small strip of metal around the two thicknesses of leather and hammer down the ends. To fasten to the watch cut a slit in the end of the leather as shown, just long enough for the fob to pass thru, and fasten as shown in No. 5.

Hat-pins, Fig. 6, tie-pins, belt-pins, and cuff-links may be made by the same method of etching and finishing as I have described, but with this difference, that before they are colored the pin stems and link backs must be soldered on.

Fig. 8. Paper-knives.

To solder them on is a simple matter after a few trials. First clean with emery cloth the place where the pin is to be soldered and rub on both the back and the pin a few drops of a solution of three parts glycerine and one part muriatic acid; place under the cap that comes on the end of the pin stems a small piece of soft solder[3] and hold both over the flame of a gas burner or alcohol lamp and the solder will melt and run, fastening the two together. Then color and finish as before.

The paper-knives, Figs. 7 and 8, are made in very much the same manner as the watch-fob, the only difference being the raising of a slight ridge down the center by laying the metal, design down,

[3]Soft solder is composed of tin and lead in equal parts melted together. See p. 88.

on a piece of soft wood and hammering it into shape with the ball end of the hammer. Polish with emery cloth, and hammer lightly and smoothly on a rounding piece of iron. A railroad spike filed smooth and driven into a block of wood serves very well for this purpose.

The athletic trophies of etched copper, Figs. 9 and 10, are good illustrations of the extent to which any of the elementary metal-working processes described in this book can be carried. The processes of transferring the design, painting, etching, cleaning, hammering, coloring, and finishing are exactly the same as those described for the making of watch-fobs. The tools and equipment required for the same, with the exception that the dish for etching would, of course, have to be much larger.

In this and the succeeding chapters, the plan is to present, in logical sequence, a series of problems in metalwork, in which, while the processes and tool requirements will be simplified as much as is possible, the chief characteristics of metalwork, namely, rigidity and durability, will in no wise be sacrificed.

Fig. 9. Athletic trophy of etched copper.
(The length of this trophy is five feet ten inches.)

Fig. 10. Athletic trophy of etched copper. (The copper plate is nineteen inches high.)

Chapter IX.

ETCHING, STRAIGHT BENDING, LAPPING.

To make the articles described in this chapter, the following new tools and equipment will be required, in addition to the tools noted in chapter VIII:

Base-plate, No. 151 F, at 40 cents.
Lapping-stake, No. 157, at 75 cents.
Smoothing-stake, No. 153 H, at 40 cents.
Wooden mallet, No. 91, one flat and one round face, at 25 cents.
Pliers, No. 106, at 15 cents.
Bunsen burner, No. 1135, at 30 cents.

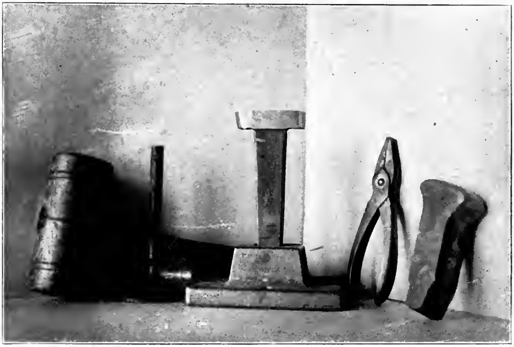

Fig. 11. Additional tools required to make the work shown.

This equipment is all shown in Fig. 11. The Bunsen burner has an adjuster at the bottom, so that it is possible to get a blue or yellow flame, as desired. The base-plate is fastened with screws to the top of a bench or table, or to a piece of heavy plank, and is used to hold the lapping-stake firmly while bending over the ends of the blotters, and sides of the blotting-pad corners and lapping over the edge of the book-ends; the mallet is used to bend the metal over and flatten out or beat up the work as needed; the Bunsen burner may be used to do the soldering on the hat-, tie-, and belt-pins,

Fig. 12. Blotters.

also the cuff-links mentioned in chapter VIII, and will also be used to obtain various colors on the copper, the process of which is described on the following pages.

STRAIGHT BENDING.

The next problem in the graded series that we are following is that of the blotter, Figs. 12 and 14. For this we shall require one piece of soft copper or brass, 18-gage (Brown-Sharpe gage) 4½″ long by 2½″ wide for the top, and one piece of spring brass, 20-gage, exactly the same size, for the bottom. The construction of the blotter is as follows: First, paint the design on the top as usual, with the sapolin, but with this difference, that we must allow an extra ¼″ on each end for turning over, as shown in Fig. 13; then etch in the acid solution and remove the sapolin in the manner outlined in the previous chapter. Beat up the design from the back on the block of wood with the ball end of hammer, getting it as smooth as possible by hammering the design on the smoothing-stake (which will fit in the base-plate) with either end of the hammer; then place it flat, design upward, on the lapping-tool, allowing the extra ¼″ on the end to project over the edge and with the flat end of the mallet bend it over the edge, as shown in Fig. 15, until it is about the same as shown in the drawing, Fig. 13, being careful that the turned-over end is at right angles to the sides.

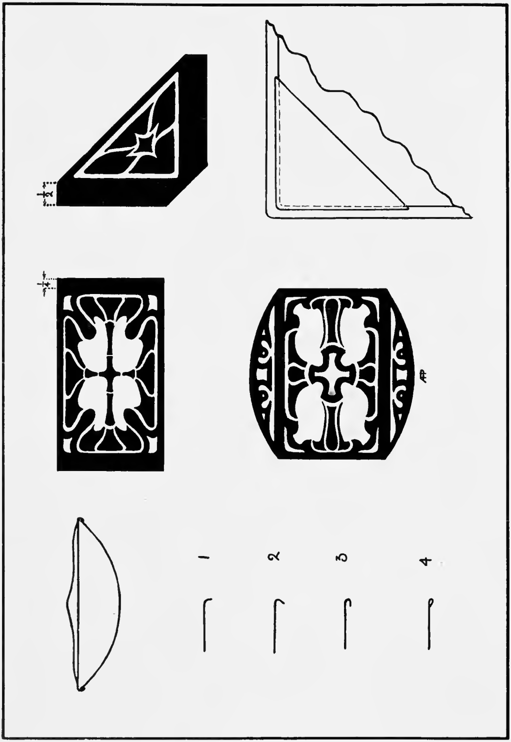

Fig. 13. Construction of blotters and desk-pad corner.

Fig. 14. Blotters.

Then proceed to color and finish in the following manner: Clean well and polish bright with a piece of old emery cloth, wire brush, or, better still, with No. 2 steel wool, which may be procured in ten-cent rolls at the hardware stores. Remember, when coloring with heat in this manner, never to allow the fingers to touch the polished surface; whenever it is necessary to handle it, do so with a piece of clean paper, as the finger-marks will show on the finished work.

Fig. 15
Bending the end of the blotters.

Now light the Bunsen burner and regulate the flame with the adjuster at the base so that the flame is blue with a small yellow tip. Hold the blotter with the pliers in the flame so that the yellow tip just touches it, passing it slowly in and out of the flame, occasionally changing your hold with the pliers, as the copper will not color under them. After a short time the copper, if it has been polished bright and clean, will change thru the various colors in this order, varying a little under different conditions:

1. Orange red.
2. Bluish-purple.
3. Brassy color.
4. Dark red.
5. Deep purple.
6. Iridescent.
7. Chestnut.

The first two colors sometimes come off when the finish is applied, so that the best colors are Nos. 3, 4, 5, 6, and 7. If you hold the copper in the flame too long—that is, beyond the chestnut color—the color will all flake and rub off, so that it is advisable when coloring for the first time to get a small scrap of copper and polish it and color it in the flame, so that you will know more readily when the right color has come. If it happens that the color does not suit you, or you carry it beyond the chestnut color and it flakes off, you can remove all the color and clean the copper by immersing in a solution of one part sulphuric acid and three parts water in a glass or earthen dish. This solution may be used cold, but will work quicker if slightly warm. Allow the copper to remain in the solution ten or fifteen minutes, then remove and rinse off in water, clean and polish with the emery cloth or steel wool, and color again. When using the sulphuric acid solution, care must be taken to allow none to get on the clothing; it will not hurt the hands, providing they are immediately washed off in water. When you have obtained a good color, allow the work to get perfectly cold, handling it as little as possible, and then flow on the banana oil and allow it to dry.

Next, cut a piece of blotting-paper the exact size of the piece of 20-gage spring brass, hold them together and place one end of the brass and paper under one end of the top, and bend and spring the other end under the other end of the top. The brass will take the shape shown in the photographs and drawing. If the ends of the top have been bent over more than 1/4″, the brass will be too long and take too sharp a bend; this is easily remedied by making the brass shorter, cutting a little off one end, and the blotter is finished. Remember that we can only color copper by heat; if the blotter top is of brass, color with the verde green or butter of antimony as described in chapter VIII.

If the students have access to woodworking tools, at school or elsewhere, a wooden block may be prepared with a curved surface to support the blotting-paper instead of the spring brass. The lower design in Fig. 13 is one that might be used with 18-gage soft copper or brass. Punch the holes for the tacks and paint in the design, which in this case may also be on the side as shown in the drawing, and etch while the metal is flat, then bend over the sides with the mallet on the lapping-tool, color and finish. Now make a soft wooden block to fit tight inside of the top and cut the blotting-paper the same width as the wooden block, but 1″ longer on each end; fasten these ends to the top of the block with small tacks, being careful to draw the blotting-paper tight. Then squeeze

Fig. 16 Desk set

Fig. 17
Bending the desk pad corner. No. 1.

Fig. 18
Bending the desk-pad corner. No. 2.

the block into the metal top and fasten it there by driving thru the holes in the sides four copper tacks, which may be bought at almost any hardware store. These blotters might be made more elaborate by making and riveting knobs and handles on the top, making use of the tools and processes described in later chapters.

LAPPING.

The next problem in order is that of the desk-pad corner. The size may be from 2″ to 4″ along the side, with ½″ allowed on each side to turn under. The method of laying and cutting out is shown in Fig. 13. The four corners may be laid out, the design painted on with sapolin, and etched all on one piece of metal and then cut out. Now bend over the two edges over the lapping-stake with the mallet, as shown in Figs. 17 and 18, being careful to keep the work square. Then place it face down on top of the lapping-stake, or on the bench-top or flat piece of wood, and bend the laps down until they are parallel with the top, with space enough between to allow of the insertion of the blotting-pad. Sometimes the metal gets hard in this bending process, especially if you do not get it just right the first time and have to bend it back. If it does at any time get hard and difficult to bend, light the Bunsen burner and adjust the flame so that it is blue without any trace of yellow, and anneal the metal by holding it in the flame until it gets red-hot, which should take about three minutes; then plunge it in cold water and you will find the metal soft again. Then continue to bend until it is right.

When you wish to clean a piece of metal that has been in the flame, it is always best to immerse it in the sulphuric acid solution and rinse in water, then polish and color by any of the previously described methods, and finish with the banana oil to retain the color. The desk-pad may be bought or made—the kind that is made of two pieces glued together, the bottom piece ¼″ larger all around than the top piece, is the best. To fasten the metal corners to the pad, loosen the corners of the pad with a knife, put a little LePage's glue inside of the metal corner, and push it on the top pad; then glue the two pads together again and allow to dry.

The book-end is the problem next in order. It requires a piece of 18-gage soft copper or brass 7″ long by 6″ wide. Of the 7″ in length we use 4″ to etch the design on and 3″ to turn under at right angles for the base.

An allowance may be made of 1/4″ all around the edge of the design for lapping over, or it may be finished without lapping the edge. Lapping the edge in this way is not difficult, and makes

Fig. 19. Book-ends.

the book-end stronger and gives a smooth edge. After the design is put on and etched (a large photographer's glass developing tray is best to etch book-ends in) and the sapolin cleaned off, with the shears cut off the surplus metal, remembering to allow the 1/4″ extra for lapping over. Then on the lapping-stake which has straight and curved edges for straight and curved outlines, lap over the edge, following the steps as shown in Fig. 13. Lap all around the edge smooth like No. 1 in the drawing; then a little more, like No. 2; then turn it over and lay it, design down, on the bench or on a block of wood and hammer it down like No. 3; and finally on the smooth surface of the lapping-stake beat down the edge lightly with the ball end of the hammer, like No. 4, as smooth as possible. Next beat up the design on the block of wood in the same way as in the preceding problems; then hammer the design carefully with either end of the hammer on the smoothing-stake, the object being to get a smooth, uniform finish all over the book-end. Now place the book-end, design upward, on the edge of a bench or table with a sharp corner, allowing the bottom part that is to be turned under to

Fig. 20
Bending the base of the book-end

project over the edge, and bend it down at right angles to the design part, with the hands, as shown in Fig. 20, and make the corner sharp and smooth with the mallet; color by any of the previously described methods, and finish with the banana oil.

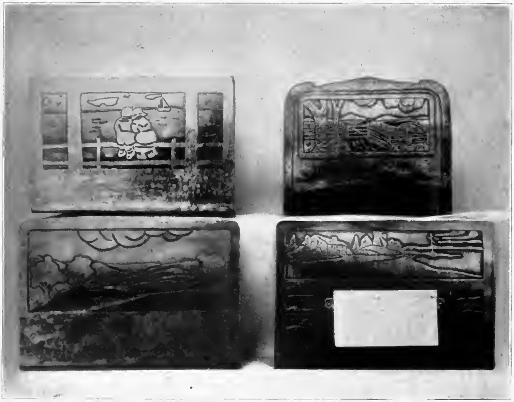

Fig. 21. Book-ends and calendar.

Chapter X.

SAW-PIERCING.

Before continuing with the series of graded problems, attention may be called to two supplementary problems similar to the book-end described in Chapter IX.

The clock, Fig. 22, is made in exactly the same manner as the book-end; a design is etched on the metal, the edge lapped over, and the base bent back in precisely the same way. It should be noted, however, that the base of the book-end is bent back exactly at right angles, while the clock is bent back at about 70 degrees. Any small round clock may be used; those in the illustrations cost $1.00 each. The legs and handle may be taken off by unscrewing, and it is then read to fit to the copper holder. Mark on the copper where the clock is to go a circle that is exactly the diameter of the clock, and inside this another circle that is ½″ less in diameter. Next, cut out the small circle as smooth as possible, either with the small chisel that was used to cut out the strap-hole on the watch-fob, or, better yet, cut it out with the saw-frame described later in this chapter. If necessary, smooth off the edge with a file, then with the ball-pein hammer on the lapping-stake turn back the extra stock to the circle that is the actual diameter of the clock, as shown in the drawing, Fig. 28, and fit the clock in tight and snug. Color and finish in any of the previously described methods. Fig. 24 shows another suggestive treatment of the clock problem.

Fig. 22. Hammered clock.

The other supplementary problem is that of the letter-rack, Fig. 23, which will require a piece of 18-gage copper or brass 10″

long by 6″ wide. A design may be etehed on the front, whieh is 3½″ high by 6″ wide; the baek is 4″ high and the bottom is 2½″ from front to back; these proportions may, of eourse, be varied slightly. The edges of both front and back may be lapped or left plain, as in the ease of the book-ends. It is better and easier to lap the edges while the metal is flat, being careful not to make the mistake of lapping the baek and front both the same way, beeause they will be opposite when bent up into shape. They should be lapped as shown in the drawing, Fig. 28. The front may be bent up as in the book-end, but to bend up the baek a pieee of hard wood will be needed —the end of a pieee of 2x4 about 10″ long would do. Bend up the baek, color, and finish.

Fig. 23. Letter-rack.

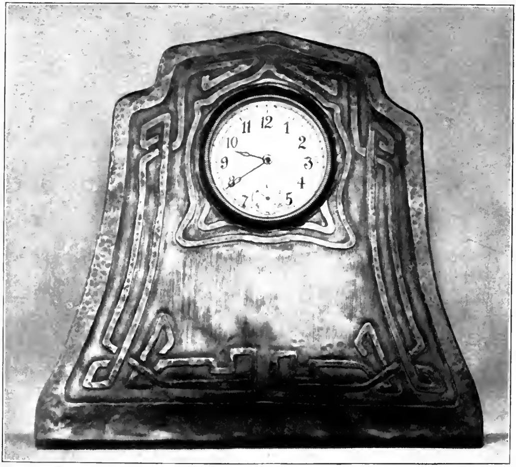

Fig. 24. Etched copper clock.

There are numerous other problems supplementary to this course. Among them is a desk calendar made on the same principle as the clock with a narrow strip riveted on to hold the calendar, also a calendar-pad holder; but enough has been said of supplementary work to show the wide variety of useful objects that can be made, and the artistic possibilities.

Fig, 25. New tools required.

When making the next of the graded problems, which is a hinge, we shall need, in addition to the tools already described, the following new tools, Fig. 25:

No. 65, Jeweler's saw-frame, 5″ deep, costing . . $ .70
No. 2, Jeweler's saw-blades, 1 dozen 10
No. K, Stake, rough cast, 15c, polished 40
No. 27, Prick or center punch 10
No. 82, Hand-drill 1.25
Drills from 3 cents to 7 cents, according to size.
1 piece of wood, $\frac{3}{4}$″ thick, 3″ wide, 8″ long, for a saw-board.

When designing a hinge, Fig. 26, it must be remembered that the first requirement is that it shall be strong enough to carry easily the door or cover for which it is made. No standard dimensions can be given, for hinges vary considerably in size and proportions according to the purpose for which they are made and the space they have to fill. Generally speaking, there are three styles of hinges: the butt hinge, in which both ends are the same, and relatively short; the strap hinge, in which one end is elongated —sometimes both; and third, the T-hinge, one of which is shown

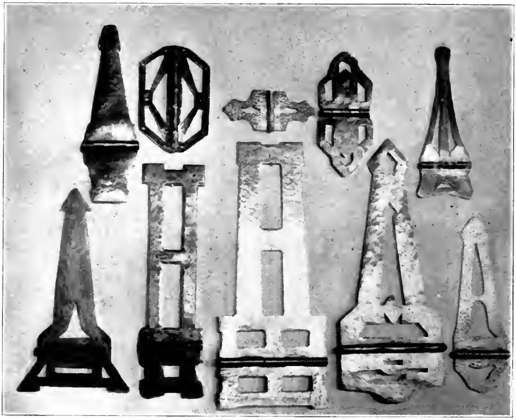

Fig. 26. Hinges.

in the drawing, Fig. 28. Examples of butt hinges and strap hinges are shown in Figs. 26 and 27.

We will take for a description of the process the making of a strap hinge. Hinges consist of four parts: the butt, which is the short end; the strap, which is the long end; and the knuckles, which fit together and are held together by the pin. There are usually five knuckles, three on the butt and two on the strap end. In other words, three knuckles on that part which is stationary when in use, and two knuckles on that part which moves.

Fig. 27. Hinges and pulls.

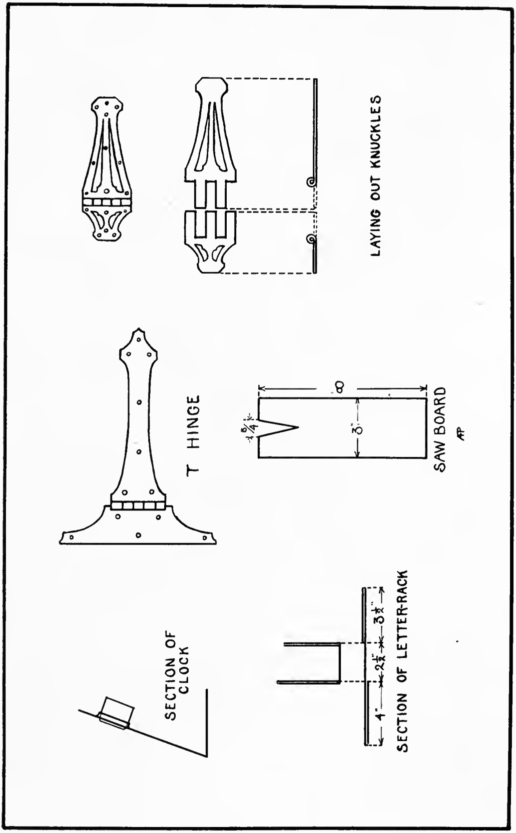

Fig. 28. Details of construction.

First make a full-size drawing of the hinge, then by means of transfer paper transfer the design of the butt end to the copper or brass. Then lay out the knuckles as shown in Fig. 28, by measuring the outside diameter and laying off three times the diameter, which will, when bent around into the knuckles, be approximately the required size. Transfer and lay out the strap in the same manner.

Fig. 29. Placing new blade in saw-frame.

Saw out the hinge with the jeweler's saw. This process of saw-piercing will require considerable care in observing a number of details; otherwise the beginner will break a number of the small, fine saws. To place a saw in the frame, first be sure that the teeth point toward the handle. This can be determined by careful inspection, as the teeth are shaped like those of the woodworker's rip-saw. Fasten the saw in the top clamp of the frame and push the top of the frame against the edge of the table or bench, Fig. 29, and the frame will give or spring just a little; then fasten the lower end of the saw in the bottom clamp. When the pressure is released, the spring of the frame will pull the saw tight. The saw will break in the work if it is not stretched tightly.

Take a small piece of metal and practice sawing before starting to saw out the hinge. Fasten the saw-board to the work-bench with screws, nails, or, better yet, with a clamp that can be bought for 10 cents. Hold the metal flat on the board with the saw in the V-shaped opening in the board and start sawing, remembering that the cutting is all done on the down-stroke. See Fig. 30. Be sure to keep the saw-blade at right angles with the metal, and moving at the rate of about two strokes per second. When changing the direction of the saw, always keep it moving up and down. This is very necessary, as the saw will break if it is twisted while still. If the saw sticks and binds, a little beeswax rubbed on the blade will sometimes help.

Fig. 30. Position of hands and saw-frame while saw-piercing.

To saw out the ornamental openings in the hinge, it will be necessary to punch a small hole thru the metal with the prick punch; then unfasten the saw from the bottom clamp and insert the saw in the small hole in the metal, spring the frame again, fasten the saw in the clamp, and proceed to saw as before. When both parts of the hinge are sawed out, bend the ends of the knuckles over on the K-stake, and continue bending until they are as nearly round as you can get them. Then get a wire nail that is large enough to fit the knuckles tight and hammer them smooth and round and fit the two ends of the hinge together. Push in and cut off a wire nail for the pin, to hold the knuckles together, then hammer the hinge smooth with either end of the ball-pein hammer. Locate the holes for the screws to fasten it to the article for which the hinge was made. With the prick punch make a small hole, and with the hand-drill drill the holes. Color and finish in any of the methods previously described.

DRAWER-PULLS.

Next we have the making of the handles and pulls for drawers, bookcases, cabinets, etc., similar to those shown in Figs. 27 and 31. A pull or handle is made up of three parts: the back, the handle, and the sockets. When designing the pull, always have the lower part of the handle fall upon the back and not upon the wood. The

Fig. 31. Drawer and door-pulls.

method of transferring the design and saw-piercing the back is exactly the same as with the hinge. Hammer the metal slightly to make it stiff and bend the edges down a very little, so that when the pull is finished and attached to the drawer, the edge of the back will rest on the wood and not rock on the bent-over part of the socket, as will be shown later. Cut off a piece of wire the length of the handle, which may be found by bending a strip of tin, or fine wire, or string, around the outline of the handle on the design and then straightening it out. After the wire is cut off the correct length, bend the ends with the hammer on the edge of the lapping-tool, and bend the rest to the outline of the design. Place the handle on the back in its proper position, and mark the place for the sockets, which are made of a strip of metal the same thickness as the back and about $\frac{1}{4}''$ wide. Bend the strip around the handle; and in the back saw out a small slit just as wide as the strip and twice the thickness of the metal, so that the two ends of the strip will fit tight when they are passed thru the slit. Next bend the ends back, one up and one down, and hammer them down with the hammer. If the edge of the back is not bent back

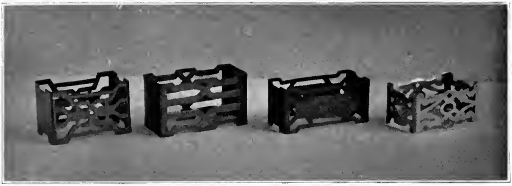

Fig. 32. Saw-pierced napkin-rings in copper, brass, and silver.

slightly, as mentioned before, the ends of the sockets will cause the back to stand out from the drawer, which, of course, is to be avoided. Mark and drill the holes for the screws to fasten to the drawer, color and finish. Keyhole escutcheons may be sawed out and the holes drilled for the fastening screws in the same manner as for the hinge.

Another interesting application of the process of saw-piercing is the making of napkin-rings in copper, brass, and silver, Fig. 32.

The first step is to get the design drawn on paper. This is easily done by folding a piece of paper twice so that when opened out again the paper has been divided into four parts by the creases. Draw with a pencil one-quarter of the design in one of the quarter-sections, then fold the paper and rub the back of the design and transfer to the other side in the same manner as described for the making of watch-fobs. Fold again and rub over the other sections, and the design is complete. The use of the mirrors held on the section lines will be found especially helpful on this problem.

Transfer the design to a piece of metal of 18-gage thickness, and saw out the design. Mark with a pencil line where the corners are to be bent. Then take a large wire nail and file the end like a blunt chisel. Place the metal on a soft piece of wood, and hold the chisel end of the nail on the corner line and strike it with a hammer, making an impression where the corners are to be. This will make a sharp corner and make the bending more easy. Bend on a piece of hard wood or iron, bringing the ends together.

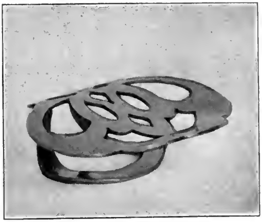

Fig. 33. Saw-pierced napkin-clip.

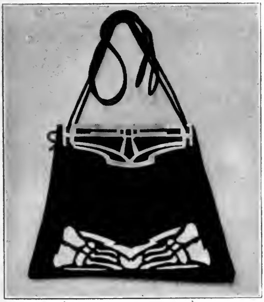

Fig. 34. Bag with saw-pierced silver top.

Fig. 35. Bag with hammered copper top.

Next we have to hard-solder the ends together. Scrape the ends with a knife to get them clean, and tie them together with a piece of thin iron wire. Cover the seam with a thin paste of borax and water. Place a small strip of silver solder on the inside of the seam and hold the seam over a blue flame until the solder melts. The flame must be hot enough to get the metal red-hot before the solder will melt.

It is now necessary to clean the napkin-ring. This may be done by placing in the sulphuric acid "pickle." In about 30 minutes it will come out bright and clean. File off any rough places, polish with a brush or with emery cloth and planish smooth on an iron stake, color, and finish.

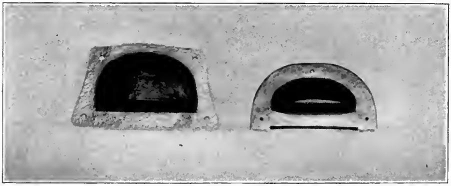

Fig. 36. Drawer-pulls.

The "napkin-clip," Fig. 33, is another easily made piece. The design is drawn in the flat, transferred to the metal and sawn out, and then the metal is bent into the form shown, and planished to make it stiff and springy. The napkin is folded and pushed into the open space.

Still another adaptation is the silver bag-top shown in Fig. 34. The construction is so apparent that no special directions are necessary, except to say that a piece of thin metal is necessary under the lining on the inside of the bag to hold the rivets that the top is fastened with. This applies also to the bag with the hammered copper top, Fig. 35.

When making the two drawer-pulls shown in Fig. 36, it is necessary to use the saw and saw-frame. A piece of metal of the right shape is cut out and a line is sawn at the place where the fingers take hold of the pull when it is finished. The metal is then beaten into a hollow in a block of wood, annealing when necessary. The final planishing on an iron stake will also stretch the metal somewhat. Care must be taken not to split the metal at the ends of the sawn line.

Chapter XI.

ANNEALING, RIVETING, SEAMING.

We have now reached the end of the first distinct division in the series of problems which we have been following. Up to this point the problems have been what we might call flat-work and straight bending problems; that is, they have been flat pieces of metal cut to shape with a design etched or saw-pierced on them, and lightly beaten into form on a block of wood with the ball-pein hammer, such as the watch-fob, paper-knife, etc. Next came the straight bending problems, such as the blotter, book-end, hinge, napkin-ring, etc.

The problems in the division which we are now beginning will teach in a simple progressive manner the construction of objects by seaming and riveting, and the process of raising a form or shape from flat metal by hammering. Annealing will also be involved.

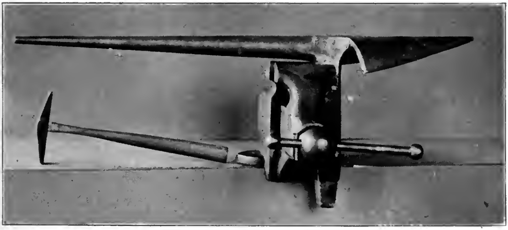

Fig. 37. New tools required.

The new tools necessary, Fig. 37, are as follows:

Iron vise with jaws 3½″ wide, cost about......$3.80
No. 7293 neck hammer, cost about............ 1.25
Tinsmith's blow-horn stake, weight 14 pounds.. 3.50

The match-box holder, Figs. 38 and 40, is a problem that involves the processes of bending, riveting, and raising. The base is raised or beaten into shape with the neck hammer, the holder is bent into form over a wooden block and riveted to the base. The detailed method of making the match-holder is as follows: Take a small match-box and measure the width, length, and thickness; the box in the photograph is $1\frac{1}{2}''$ wide, $2\frac{1}{4}''$ long, and $\frac{3}{4}''$ thick. A piece of copper is cut out that will cover the two sides and one end. For a box of the above dimensions the piece of copper is $5\frac{1}{4}''$ long and $1\frac{1}{2}''$ wide. If a design is to be etched on the sides, it is easier to do it at this time, while the metal is flat.

Fasten in the vise a piece of wood that is the same thickness as the match-box, and with the hammer and mallet bend the copper over the wood and into shape, so that the box fits rather tight. Next cut a strip of copper $3\frac{1}{4}''$ long and $\frac{1}{2}''$ wide and bend it with the pliers into shape as shown in the drawing, Fig. 39. This is to slip inside of the box cover and raise the box so that the

Fig. 38. Match-box holders.

matches can be easily removed. To make the base, cut a rectangular piece of copper $4\frac{1}{2}''$ long and $3\frac{1}{2}''$ wide, 18-gage thick; mark in the middle the size of the raised part upon which the box-holder is to be riveted, and hammer it into shape with the neck hammer on a block of wood held in the vise. Care must be taken to strike the copper just off the edge of the block of wood, as shown in No. 1, Fig. 39, then the metal will give and bend, as shown in No. 2.

ANNEALING.

After the metal has been hammered and raised partly into shape it will get hard and stiff, and it will be necessary to "anneal" it.

This may be done over the Bunsen burner or over a gas range, in a furnace—in fact, in any place where there is heat enough to get it red-hot. After it has been heated to a dull red heat it is plunged into water while hot, or laid aside to cool, after which it will be found to be soft and pliable again. It makes no difference

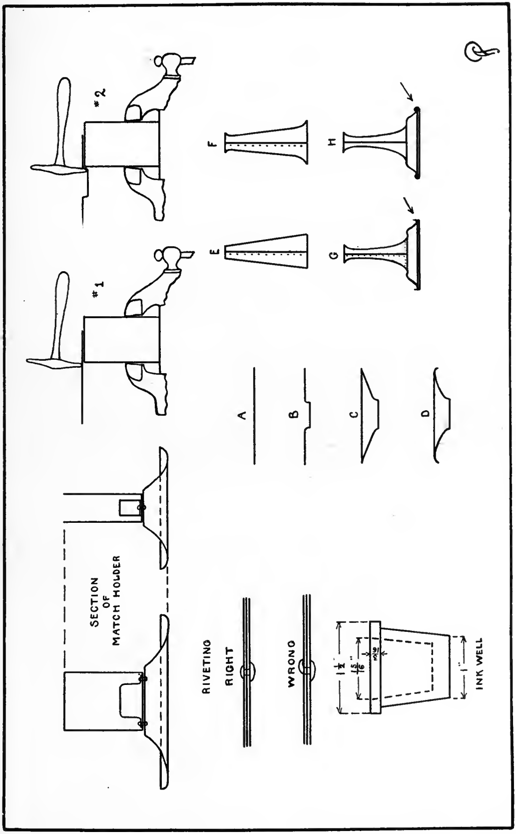

Fig. 39. Details of construction.

which method is used to cool the metal, as it is the heating that makes it soft.

We may now continue hammering and raising it into shape, the progressive steps of the raising being shown as A, B, C, D, Fig. 39. To bend up the edge, as shown in D, hammer with the flat side of

Fig 40. Match box holders.

the ball-pein hammer over the edge of the block of wood. To finish the base, hammer with the neck hammer in regular even strokes on the No. 157 lapping-stake.[4]

RIVETING.

We now have three pieces of copper that are shaped and hammered ready to be riveted together. The rivets may be of copper tacks cut off to the required length. Drill a hole the diameter of the tack in each end of the small piece that slips inside the box-cover, and placing that in its proper position inside the piece that holds the match-box, mark and drill the holes. Next place the box-holder in its proper position on the base, mark and drill the holes in the base. We now have in each of the three pieces two holes which will all correspond when in position. Care must be taken

[4]See Fig. 11, p. 64.

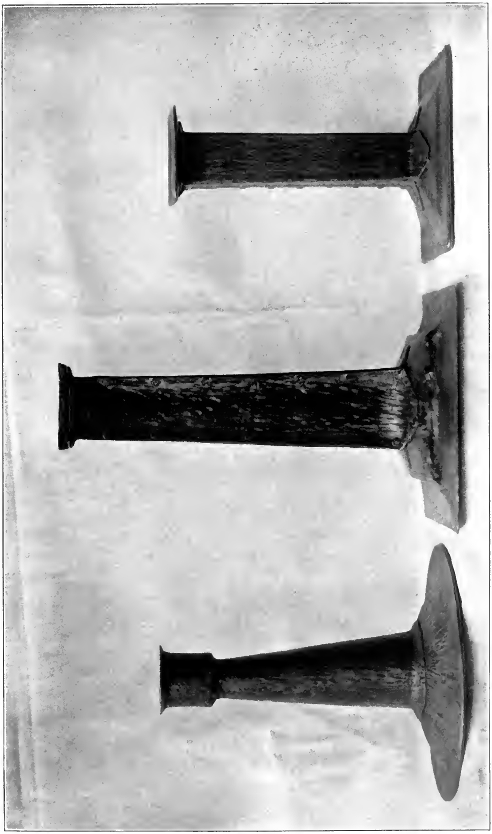

Fig. 41. Candlesticks.

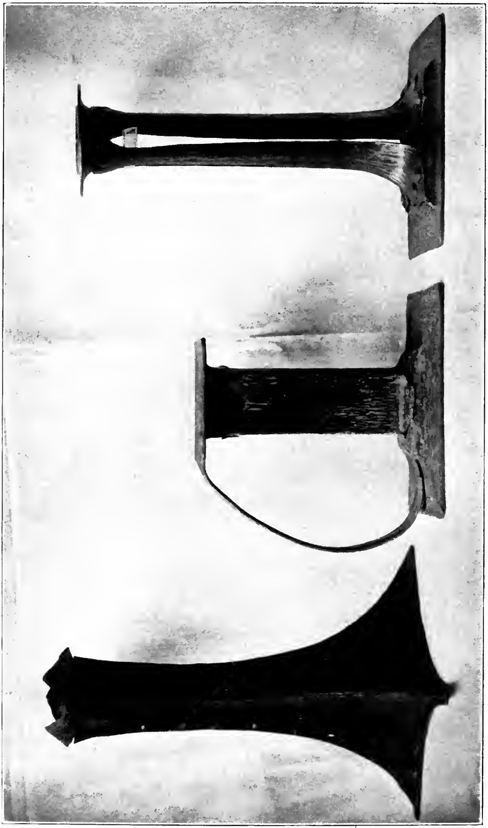

Fig. 42. Candlesticks.

to have the head of the rivet rest on something solid; in this particular case, the head of a large nail held in the vise will do. Let the point of the rivet come on the under side of the base and be careful to hammer the rivet as shown in the drawing, Fig. 39. Color and finish in any of the previously described methods.

The next problem, the candlestick, may be constructed in many different ways, Figs. 41, 42, and 43, but all are made up of the same number of parts: base, pillar, socket, and sometimes handle. Those made with a round base and pillar with a glass ink-well for the candle-holder are the easiest to make. The glass ink-well referred to is the ordinary desk ink-well in common use in the public schools, and can be bought for forty cents a dozen. The dimensions of the well are given in Fig. 39.

SEAMING.

To make the round candlestick, make a paper pattern of the pillar, remembering that the top must be large enough to hold the ink-well, also to allow enough extra metal at the seam to lap over and rivet. Cut it out of the flat copper and with the prick punch mark the places for the rivets along one of the edges; then bend the copper around the blow-horn stake, beating it with the mallet until the edges lap over. Drill the holes for the rivets, and rivet the end holes first. Always place the heads of the rivets inside the pillar, and rivet one at a time on the blow-horn stake. If any difficulty is found in getting a rivet into its hole, place the rivet point upward on a flat file, insert in the tube, and the rivet will easily pass into the hole.

The pillar will now have straight sides and look something like E. Fig. 39. Bend out the top and bottom on the blow-horn stake with the neck hammer until it looks like F in the drawing, being careful not to break any of the rivets. If a larger top is desired, cut out a piece of metal and rivet on top, as shown in the photographs. Now hammer smooth with the flat face of the ball-pein hammer and with the neck hammer, and it is ready for riveting to the base.

The base is made by cutting out a circular piece the size wanted and beating into shape in a depression in a block of wood, hammering it smooth with the ball-pein hammer on the No. 153, H, smoothing-stake.[5] Wherever possible, avoid leaving the raw edge of the

[4]See Fig. 11, p. 64.

Fig. 43. Candlesticks

copper, as it is likely to scratch and scrape anything it comes in contact with. For instance, if we should leave the edge of the base as it is now, it would scratch any table or piece of furniture it might be placed upon. It would also be liable to get bent out of shape. To avoid this, we will lap the edge of the base up or down by the process used in the case of the book-end. Then rivet the pillar to the base.

Fig. 44. Copper lamp trimmed with brass.

If it is desired to make a better and more finished piece of work, the base may be made more solid and substantial by lapping another piece of flat copper on to the base instead of merely lapping the edge. This is done by cutting out another piece of copper ¼″ larger in diameter than the base of the candlestick, turning the edge of the flat piece over at right angles on the lapping-tool, and fitting the base into it, as shown at G, Fig. 39; then with the neck hammer carefully bend the edge over on to the base and hammer down smooth, as shown at H in the drawing. Color and finish by any of the previously described methods.

For a square candlestick, the process is similar, except that the base is raised into shape in the same way as the match-holder base, and the pillar is shaped on a square piece of iron or steel.

Candlesticks may be made without the use of the glass ink-well, by making the top smaller and filling the pillar nearly full of plaster of paris mixed with water. The plaster will support the candle and stop it from dropping down too far

The table lamp shown in Fig. 44 is a logical development of the candlestick problem. The construction is substantially the same, the only difference being that the pillar is larger, and arms are added to support the shade. These arms are made of round copper wire flattened at the end and riveted to the pillar.

Fig. 45. Riveted napkin-ring.

In this and the preceding chapters, copper has been specified for the problems to save repetition of words, but brass may be used instead of copper in every case. The same instructions apply to both brass and copper, except in coloring, as has been previously explained.

The napkin-ring shown in Fig. 45 is an interesting problem in riveting. It was made from a piece of flat copper 6″ long by 2″ wide. The ends are beveled with a file, lapped over about $\frac{3}{16}$″, with three holes drilled or punched thru for the rivets. After it is riveted the edges may be hammered out in many interesting shapes, one of which is shown.

The napkin-ring shown is one of many made by seventh and eighth grade girls in a one-room country school, with very limited equipment.

Chapter XII.

CONSTRUCTION, RAISING, PLANISHING.

The next problem of this series is the electric lantern, the construction of which involves straight bending, riveting, and raising, the same as the candlesticks shown in chapter XI.

The photographe show four distinct styles of supports and fastenings for the lantern: some are made to hang from the ceiling, Figs. 49, 52, 55, 57; others, from the side wall, Figs. 46, 47, 50, 51, 54; one is a desk or piano light, Fig. 56; and two are table lights, Figs. 53, 55. The construction of the lantern itself is the same in all cases, varying only in the size and design, and the material may be either copper or brass. The parts of the lantern are the handle, top, four corners, four top cross-pieces, four bottom cross-pieces, and eight small pieces to hold the glass. The various parts are held together wholly by rivets, a method of construction which makes a strong, durable piece of work and adds greatly to the decorative effect. Soft solder should never be used on work of this kind, as it will soon break away, making the work a constant source of annoyance instead of an object of utility and beauty.

Fig. 46. Electric lantern.

Fig. 47. Electric side light.

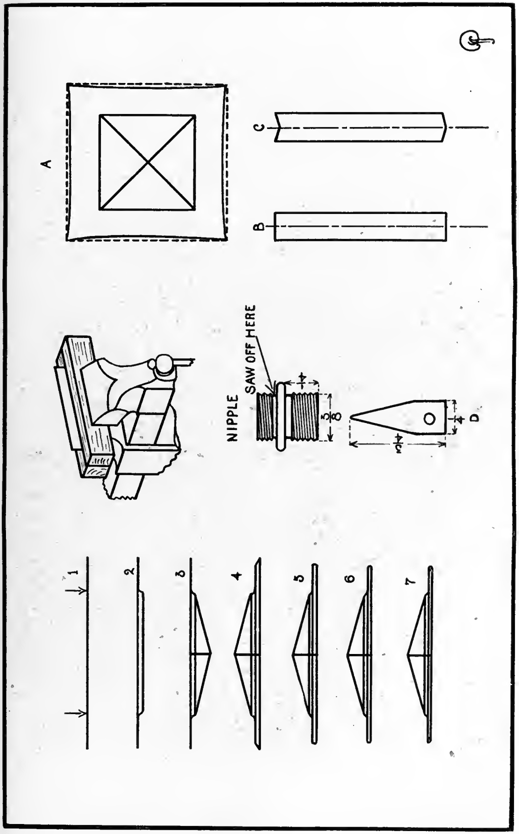

Fig. 48. Details of construction.

It is best to make the top of the lantern first; this is usually from 5″ to 7″ square. Always cut the metal for the top ½″ larger than the finished top is to be. This extra ½″ is to allow for squaring and lapping the edge. When the metal is cut to the required size, draw a pencil line parallel with the edges, where the top will start to be beaten or "raised" upward. The location of this pencil line is indicated by the arrows on the drawing, No. 1, Fig. 48.

With the neck hammer beat down the metal over the edge of a block of wood held in the vise, using the method shown for the match-holder base.[6]

Fig. 49. Lanterns.

RAISING.

The progressive steps for the "raising" of the lantern-top are shown in Fig. 48. No. 1 is the flat piece of metal cut ½″ larger than the finished top. No. 2 is the way it should look after beating it over the edge of the block with the neck hammer. It is probable that the edge will at this time bend slightly out of shape; if it does, place the top on a flat piece of wood and flatten the edge with the wooden mallet. To proceed to No. 3, draw pencil lines from corner to corner on the inside of the bottom of No. 2, intersecting at the center. Procure a block of hard wood (maple is best, but oak will do) 3″ square and 7″ long, and with a gouge cut a depression in one end about ½″ deep. Fasten the block in

[6]See Fig. 39, p. 87.

the vise, hold the lantern-top over the depression, and with the neck hammer beat the metal along the pencil lines, hammering a little harder in the center where the lines intersect, being careful to hammer only on the pencil lines. This will make the top look like No. 3. Care must be taken during this process to keep the


Fig. 50 Lanterns. Fig. 51

lines square and straight. If it is desired to raise the lantern-top to a high, sharp peak, it will be necessary to raise it part way and then "anneal" it by the process described in chapter XI.

After the top has been made like No. 3 it will be found that the sides have been drawn in by the hammering, as shown in the sketch marked A, Fig. 48. It will, of course, be necessary to straighten the sides by cutting with the shears, and then we may proceed to lap the edges as shown in Nos. 4, 5, 6, and 7, altho it is not always necessary to carry this process thru Nos. 5, 6, and 7. If we turn the edges down as in No. 4 it will be satisfactory in most cases. Some of the lanterns shown in the photographs were finished like No. 4, but if it is desired to carry the lapping process thru to No. 7, the process is exactly like that described for the book-ends in Chapter IX.

After the top is raised to the desired height and the edge finished, it will be necessary to hammer it all over with one of the hammers on either the No. 157 lapping-stake or the 153 H smoothing-stake.[7] This final hammering, besides offering an opportunity

Fig. 52 Metal and glass lanterns.

to square and true the work, stiffens and hardens the metal, and covers the surface with hammer marks which add greatly to the charm of the finished piece of work if it is carefully done. This process is known among professional metalworkers as "planishing," and the process of beating and hammering the flat metal into shape is known as "raising."

These terms will be used hereafter in this series to distinguish one process from the other.

PLANISHING.

The term planishing meant to the metalworkers of years ago the process of smoothing and stiffening the metal by hammering it carefully with the smooth flat face of a planishing hammer. In our case it would be with the flat face of the ball-pein hammer.

[7] See Fig. 11, p. 64.

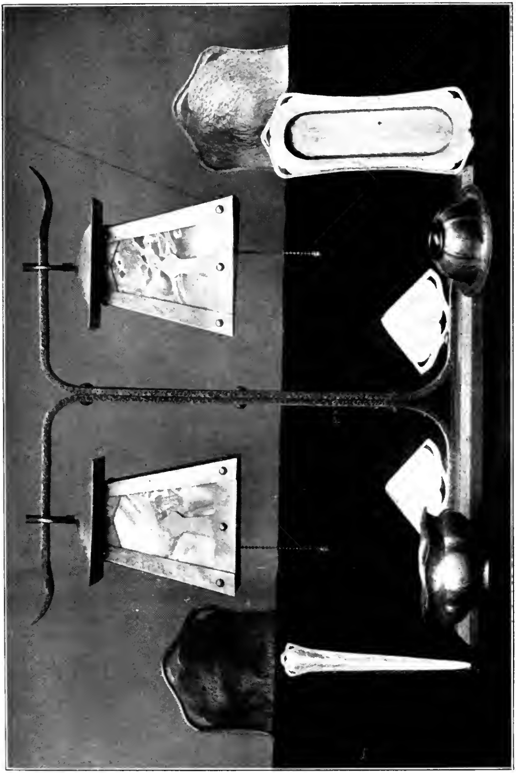

Fig. 53. Table lamp and desk accessories.

Within the last few years the custom of hammering the metal with the ball end of the hammer and with the neck hammer has also been called planishing. All these methods were used on the lanterns shown in the photographs and may readily be distinguished by the long narrow marks of the neck hammer, the small distinct round marks of the ball end of the hammer, and the smooth, almost invisible, marks of the real planishing with the flat end of the hammer. For the beginner the easiest method is to planish with the neck hammer or the ball end of the ball-pein hammer.

Now the lantern-top is ready for the hole thru which the electric wires pass. This hole should be 3/8″ in diameter. It may be bored thru with a drill, or sawn out with the saw-frame used on the drawer-pulls and hinges.[8]

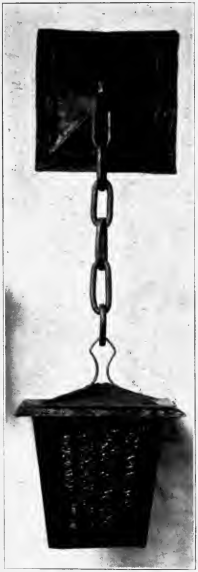

Fig 54. Lantern.

The hole is made 3/8″ in diameter because that is the size of the small brass nipple that is used to hold the electric socket in the lantern. These nipples cost five cents each and may be obtained from any dealer in electric supplies. There is a thread on both ends, but as only one is necessary the other may be sawn and filed off as indicated in the drawing, Fig. 48.

It is now necessary to make the handle and rivet it on the lantern-top. This handle may be made of round wire flattened at both ends to allow of riveting, or it may be made of a strip of flat metal cut out and bent to shape. When riveting the handle to the lantern-top have the head of the rivet on the outside. These rivets are known as oval head rivets, —the term oval applying to the cross-section view of the head which is half oval. The heads of the rivets used on the lanterns in the photographs were $\frac{3}{16}$″ and 1/4″ in diameter. They are known as No. 12 trunk rivets, and may be obtained at almost any hardware store.

[8]See Fig. 25, p. 75.

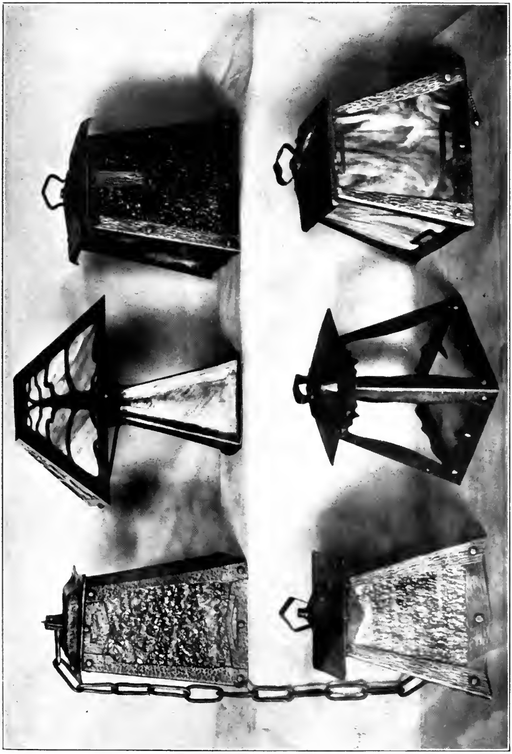

Fig. 55. Lanterns and table lamp.

After the handle is fastened to the top, cut a paper pattern for the corner pieces. If the lantern is to be the same size at the bottom as it is at the top the pattern will look like B, Fig. 48, but if it is to be wider at the bottom than at the top, the pattern will look like C. Cut out the corners from the flat metal and planish them with the same hammer used in planishing the top. If they get very hard from the planishing, soften them by "annealing."

Then draw a pencil-line down the center where the corners are to be bent at right angles. To bend the corners, get two pieces of hard wood about 10″ long x 1″ thick x 2″ wide, and place the copper between the pieces of wood so that the center-line comes

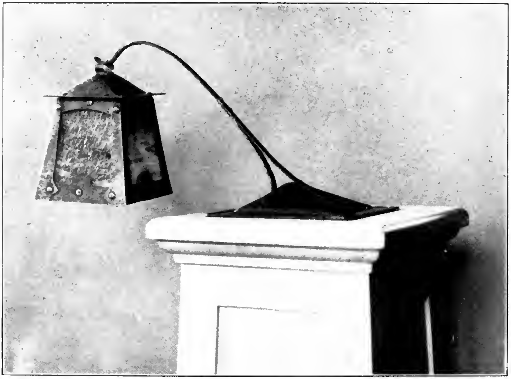

Fig. 56. Desk or piano lantern.

exactly to the edge of the wood as illustrated in the sketch, Fig. 48. Fasten in the vise, and with the mallet carefully and smoothly hammer over at right angles the part that projects above the wood.

In making the paper pattern of the top cross-piece, allow ¼″ extra metal along the edge that goes next to the top for the purpose of riveting the body of the lantern to the lantern-top. Planish the cross-pieces to match the top and corners, and bend the extra ¼″ over at right angles between the two pieces of wood as before. Cut out and planish the bottom pieces.

The photographs show a rivet in the center of each bottom and top cross-piece. The purpose of this rivet is to hold a small piece of sheet copper of the dimensions indicated at D, Fig. 48. These pieces are made of 24-gauge soft copper.

After the lantern is colored and finished, this small piece of copper is bent over on to the glass to hold it in place. It is better to cut out and rivet these pieces on the cross-pieces before the cross-pieces are riveted to the corner pieces. Next locate and drill the holes in all the pieces excepting the top, and rivet the lantern together. Then place the top in position, mark and drill the holes, and rivet the top on to the lantern and it is ready for coloring and finishing.

FINISHING WITH WAX.

For finishing the lantern a new process is suggested, that of waxing. This finish is much better for the larger pieces than banana oil. The wax finish is prepared and used in the following manner: In a tin cup melt some beeswax; when it is liquid move away from the fire and pour in an equal amount of turpentine, stir together and set aside to cool. Color the lantern by any of the previously described methods of coloring, or polish as bright as possible with the steel wool or emery cloth and leave bright. After the desired color is secured, warm the lantern over the bunsen burner, or any other flame that will not smoke, and with a small piece of cloth rub on the lantern a small amount of the wax. The lantern must be warm enough to melt the turpentine and beeswax as it is applied, but not hot enough to cause the wax to smoke. After the wax has been rubbed lightly and rapidly over the lantern, allow it to get perfectly cold, then polish briskly but lightly with a soft, clean cloth. The finish gives a soft sheen to the metal that preserves the color indefinitely and adds materially to the beauty of the finished article. It remains only to put in the glass and bend over the glass holders, and the lantern is finished.

Fig. 57. Hanging lantern.

Chapter XIII.

BEATING DOWN, FLUTING, MODELING.

The square smoking set, Fig. 58, is shown not as a regular problem in this course, but to give some idea of the possibilities that lie in the development of the processes of bending and riveting. It was made almost entirely from flat metal by bending, the only "raising" being on the cover of the box and the base of the match-box holder, which was done in the manner described for the lantern-top. The large tray, the ash-tray, and the box, were all made in

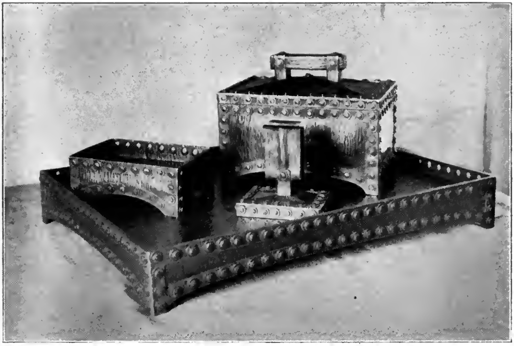

Fig. 58. Smoking set.

practically the same manner; a rectangular piece of copper was cut to size; then the corners were snipped out with the shears and the sides and ends bent up, forming the tray or box; the side and end pieces were next cut to shape and fitted; then the brass trimming along the edges was fitted to its place, these together making three thicknesses of metal at the top edge and two at the bottom edge. The holes were then drilled and the rivets put in.

This set is also a good example of the use of construction as a feature of the decoration.

The fireplace hood, Fig. 59, shows another possibility of bending and riveting. The design on the front was beaten up from the

Fig. 59. Fireplace hood.

Fig. 60. Humidor.

back with the ball end of the ball-pein hammer. Another problem that may be constructed by bending and riveting is the humidor shown in Fig. 60. A flat piece of copper was cut to size, bent round, and the seam drilled and riveted; the feet were cut out and shaped; and a tight-fitting bottom was driven in from the top and held by parts of the edge bent under at the bottom.

The next regular problem in the series we are following is the round plate, Fig. 61. This may vary in size according to its use. The card-tray is usually from 5″ to 7″ in diameter and rather shallow. The fruit plate is from 9″ to 12″ in diameter and rather deep, with a wide border.

The method of making a round plate of any diameter is as follows: Cut out of 18-gage soft copper or brass a circle ¼″ larger in diameter than the plate is to be; next, lap over the edge

$\frac{1}{8}''$ all around the flat piece of metal in the manner described for lapping the edge of the book-ends, Chapter IX., being careful to follow the steps as shown in the drawing, Fig. 13. When lapping

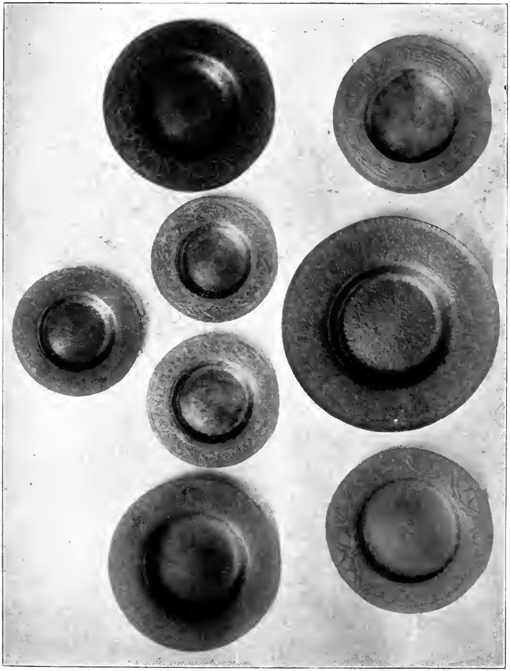

Fig. 61. Round plates.

over the edge be careful not to strike the hammer on the flat part of the copper, as that will make a disfiguring mark that will show on the finished plate.

If it is desired to etch a design around the border, Fig. 62, the design must be painted on after the edge has been lapped over, remembering that the design must be painted on the side opposite to that on which the lap is seen. Paint the design on with sapolin; then etch it, and remove the sapolin according to the directions given in Chapter VIII.

BEATING DOWN.

Next beat down the depression in the plate. Draw a line with the pencil dividers where the depression starts; then hold the plate on the end of a block of wood and beat it down on the edge of the

Fig. 62. Plates with etched designs.

block with the ball-pein hammer along the pencil line, Fig. 63. If the plate is to have a deep depression, it will be necessary to anneal it, because it gets hard while being beaten down.

ACID CLEANING SOLUTION.

Annealing a piece of work usually makes it dark and dirty, owing to a thin coating of black oxide that forms on copper when it is heated. To clean it, immerse for about ten minutes in a solution of one part sulphuric acid and two parts water; then wash in running water. Be careful not to get any of this acid solution on the clothes, as it will destroy the cloth. It will not hurt the hands if it is immediately washed off with cold water.

Now polish the plate with emery cloth or steel wool, or, better still, with the wire polishing brush, Fig. 64, and it is ready for the process of planishing described in Chapter XII.

Fig. 63. Beating up the round plate.

For the planishing of the plate the following new tools will be needed, Fig. 64:

No. 10 bottom-stake, costing 65 cents.
No. 146-A tee-stake, costing 75 cents.
Wire polishing brush, costing 30 cents.

Fig. 64. New tools required.

After the plate has been well polished, put the No. 10 bottom-stake in the vise and hold the plate on top of it. Start planishing the bottom of the plate in the center with the flat face of the ball-pein hammer, gradually working out toward the edge, Fig. 65.

Do this planishing carefully, striking lightly with the center of the hammer. It is not necessary to raise the hammer more than four inches away from the plate to get a blow of sufficient force. When the bottom is smooth it should be slightly raised in the center so that the plate will rest on the outer edge of the bottom. To planish the side of the plate put the No. 146-A tee-stake in the vise and planish from the outside. Next, place the edge or border of the plate on the lapping-stake, and beat it flat and smooth with the mallet. The plate is now ready for polishing, coloring, and wax-finishing by the previously described methods.

Fig. 65. Planishing the side of the plate.

The large oval serving tray, Fig. 66, was made in exactly the same way as the round plate, excepting that the edge or border was planished the same as the bottom. Handle may be made of heavy round wire and riveted on, or holes may be cut out with the jeweler's saw, and the edge lapped. See also Fig. 72.

FLUTING AND MODELING.

To make the fluted and modeled plates shown in Fig. 67, first lap the edge, then beat down the depression, and anneal as de-

Fig. 66. Serving tray.

Fig. 67. Fluted and modeled plates.

scribed before. Then get a piece of hard wood about 8″ long, 2″ wide, and 1″ thick, and on the end file a flute the same shape as you wish to reproduce on the plate border, and with the end of the neck hammer that fits the flute best, beat the plate border into the wooden model; then polish and finish.

Fig. 68. Rectangular trays.

The rectangular trays, Figs. 68, 69, 70, and 71, are made in a little different manner from the round trays, the method being as follows: Cut out a piece of metal about ½″ larger than the finished tray is to be; on the edge of the block of wood beat down the depression with the neck hammer; then cut the tray to the desired outline and lap over the edge; planish and finish. The reason for this difference in method between the round and rectangular trays is that the sides draw in on any square or rectangular piece of work in the same way as shown in the drawing of the lantern-top in Chapter XII.[9].

The problems described in this and the preceding chapter call for painstaking care and attention to details, and as it is not possible to make a good lantern or plate without some previous experience, the easiest and best way is to start at the beginning of

Fig. 69

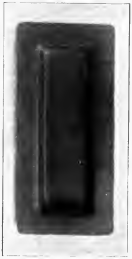

Fig. 70

Fig. 71

Rectangular desk trays.

the series and make at least one of each of the problems described. In that way the student will become familiar with the tools and processes. He should remember that it is always better to have one good piece of work than many poor pieces.

Fig. 72 Serving tray with wire handles.

[9]See Fig. 48, p. 97.

Chapter XIV.

OUTLINE CHASING, RAISING.

At this particular stage in the development of this course, the problems that could be made are so numerous and the possible development of processes so extensive, that it seems worth while to call attention to some of these problems and developments.

Fig. 73. Crumb tray and scraper.

The crumb-tray and scraper shown in Fig. 73, are problems supplementary to the round plate, the same tools and processes being used. The metal is cut to shape, the edge lapped over, the design painted on and etched, and the depression beaten down over the edge of the wooden block, and planished and finished in the same way as the plate. The only difference is in the method of planishing the bottom of the tray and scraper; the straight front edge of the bottom must be planished first, crossing from one side to the other in regular even rows, planishing the deepest part of the depression last. The reason for this difference is that if the front edge is hammered last, it will stretch and swell upward and will not lie flat, thereby making it unsuitable for the use for which

Fig. 74. One side of "dome" with design traced on, and one half "chased."

it is intended, which is after all the final test of any piece of arts and crafts work.

OUTLINE CHASING.

In this course we have thus far used four decorative processes outside of coloring, namely, etching, saw-piercing, planishing with the neck hammer, fluting and modeling. The electric light dome shown in Fig. 77 is a development of the lantern problem, and introduces a new process called "outline chasing," a process which

Fig. 75. Method of "chasing."

is entirely suitable for public school work. Fig. 74 shows a piece of 20-gage copper tacked to a piece of one-inch board, with the design traced on one half and "chased" on the other half. This chasing, which is only the simplest kind of metal chasing, is done with two small chisel shaped tools that are called straight and curved tracers, and the ball-pein hammer.

The tracers can easily be made from a piece of $\frac{3}{16}''$ square steel rod, and should be about $4\frac{1}{4}''$ long; one end should be filed to an edge like a small chisel, except not so sharp, with the edge dull and slightly rounding, so as to avoid cutting thru the metal. The edge of the curved tracer is filed so that the curve is about the same as a small section of a $\frac{3}{4}''$ circle. The tools and the correct position of holding and using them are shown in Fig. 75. It is rather difficult to follow the lines at first, so it is advisable to practice a little on a scrap piece of copper tacked to the board. Do not make a very heavy line the first time, but go over it a second and third time straightening and correcting it.

Fig. 76. Side of "dome" chased, and background cut out ready to bend in shape.

Fig. 76 shows the side of the dome chased, and the background cut out with a chisel, made and used in the same way as the chasing tools, except that it has a cutting edge which is kept sharp to cut thru the metal. After the chasing is done, and the background cut out, the metal is removed from the board, cut and bent to shape, and riveted together into the finished dome which is shown in Fig. 77. The ceiling plate was raised into shape and planished, in a manner similar to that described for the lantern-top in Chapter XIII.

Another adaption of this new process is shown in the sterling silver plate, Fig. 78. The same chasing tools were used as in the chasing of the dome, the steps in the process being: *First,* tack

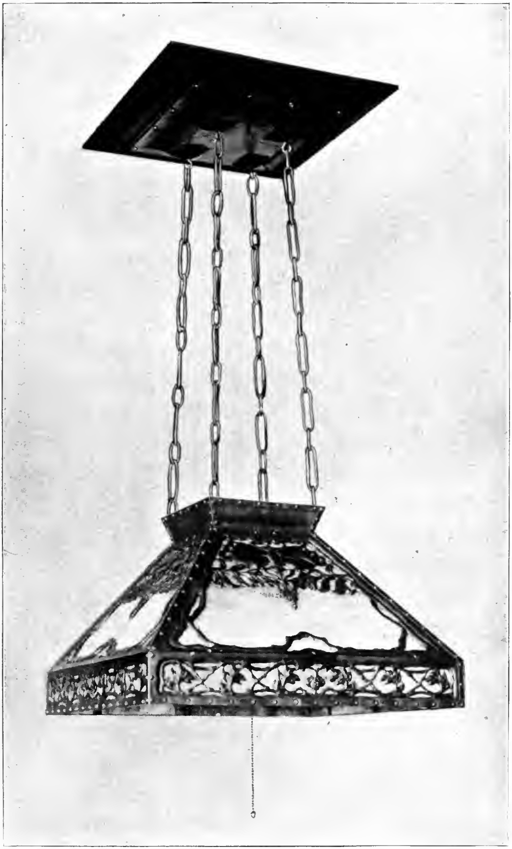

Fig. 77. Electric light dome.

the flat piece of metal to the board by driving tacks thru the metal as near the edge as possible; *Second,* trace on the design; *Third,* chase the design; *Fourth,* remove from the board and trim the edge of the tack holes; *Fifth,* lap the edge; *Sixth,* beat down the depression; *Seventh,* planish and finish. See also Fig. 79.

Fig. 78. Chased silver plate.

RAISING A BOWL.

The next regular problem in our series, the small bowl, is distinctly a "raising" problem; that is, it is completed entirely by the process of raising from a single flat piece of metal.

There are three distinct methods of raising a shape from the flat metal, any one or all of which may be used, depending upon the shape of the object to be raised. The simplest and commonest method is that of forming the shape by beating it into a depression on a block of wood, or over the edge of a block, as in the cases of the match-holder base, lantern-top, and plate, already described.

The simplest form of the problem is the round pin-tray with a flat bottom, made from a circular piece of copper or brass about 4″ in diameter. This problem can be adapted to a variety of uses, with the same tools and methods as described, by varying slightly the processes. By using a circular piece of 20-gage sterling silver 8″ in diameter, a dainty little salt dish can be made. From a piece of silver 5″ in diameter can be made a dish for candies or almonds. By beating a 5″ piece of copper or brass as deep as the hammer will allow we can make a jar for violets or other short stemmed flowers. By inverting it and placing a glass ink-well inside and lapping a bottom on, we have an ink-well that is steady on its base. And by using an 8″ circle we can make a serviceable nut-bowl. All of these types are illustrated in the photographs.

Fig. 79. Bowl with chased design.

For a description of tools and processes, we will take the round pin or ash-tray made from a circular piece of 10-gage copper or brass 4″ in diameter. See Figs. 80 and 83. Secure a block of hard wood about 3″ square and 6″ long. Place this block upright in the vise and in one end cut with a gouge a circular concave depression, about 2″ in diameter and $\frac{1}{2}$″ deep in the middle. If you cannot obtain a gouge, it is possible to hammer this depression in by striking the block with the ball end of the hammer.

With a pencil compass find the center of the piece of copper, and draw a circle the size the bottom of the bowl is to be. In a 4″ circle the bottom should be about 2″ in diameter, leaving 1″ all around to form the sides. Next place the flat piece of copper over the depression in the block and with the ball end of the hammer beat the copper down into the depression, as shown in Fig. 81 and in sketch 1, Fig. 82. Strike a single row of blows all around the circle and this will raise the copper to the shape marked A, Fig. 82. Then tilt the bowl as shown in 2 and strike another row of blows with the hammer all around, about half way between the first row and the edge of the metal; this will raise the bowl to

Fig. 80. Copper and brass bowls.

a shape similar to B. Now tilt the bowl as shown in 3, and strike with the hammer another row of blows near the edge of the bowl, this will make the shape about the same as C. Continue this process until it is fairly smooth and even and the shape you wish.

The bowl may now be polished and planished, and a simple

Fig 81. Raising a bowl.

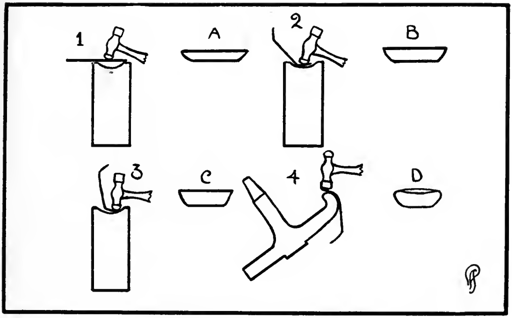

Fig. 82. Steps in raising a bowl.

design etched around the edge, on the inside on the bottom; or the shape may be made more interesting by beating over the edge as is shown in D, Fig. 82. This may easily be done by fastening the tee-stake [10] in the vise, in the position shown in 4, Fig. 82, and holding the edge down to the stake, bringing it to the shape shown at D. If the bowl is to be rather deep, the metal will probably become hard and unyielding. If it does so, anneal it, clean as described in Chapter XIII, and continue hammering, remembering to strike even, regular blows all around the bowl. If you strike harder on one side than on the other, the bowl will not be true and even in shape. The regular even hammer marks on hand-made

Fig. 83. Pin tray and ink well.

[10]See Fig. 64, p. 111.

Fig. 84. Pen-tray and ink-well.

metalwork give to it a beauty and charm that is impossible to reproduce by any other means. A bowl that is uneven and has been chopped and banged at with a hammer, is just so much good metal spoiled, but one that is smooth and true showing the honest marks of the process used in bringing it to form, is an object of utility and beauty, something to take pride in, use, and treasure.

Fig. 85. Saw-pierced bowl with glass lining.

Chapter XV.

RAISING, FLUTING, PANELING, NECKING IN.

The problem of making the small bowl described in Chapter XIV leads naturally to the problem of the nut-bowl, which is the same in principle, using the same tools and methods, but requires a larger disk of metal. It also opens up a splendid opportunity to illustrate and use a characteristic and typical method of decoration for sheet metal forms, namely, that of fluting, sometimes called shaping or modeling.

The first bowl in Fig. 86 shows the simplest and easiest form of fluting, and it will be used for the purpose of describing the process. For a nut-bowl a circular piece of 18-gage flat copper or brass is cut out from 7″ to 10″ in diameter. It is then "raised" to shape by the method described for the small bowl.

FLUTING.

After the bowl has been raised to a form that is true and even, we are ready for the process of fluting, the first step of which is to divide the bowl into 5, 6, or 7 parts by drawing vertical pencil

Fig. 86 Copper nut-bowls, concave fluting.

lines down the sides where the flutes are to come. The above number of divisions is suggested because it is one of the well-known rules of design that it is usually best to divide such forms into 5, 6, or 7 divisions.

The next step is to make a fluting block,—a piece of some hard wood, preferably maple, about 12″ long x 2″ wide x 1½″ thick,

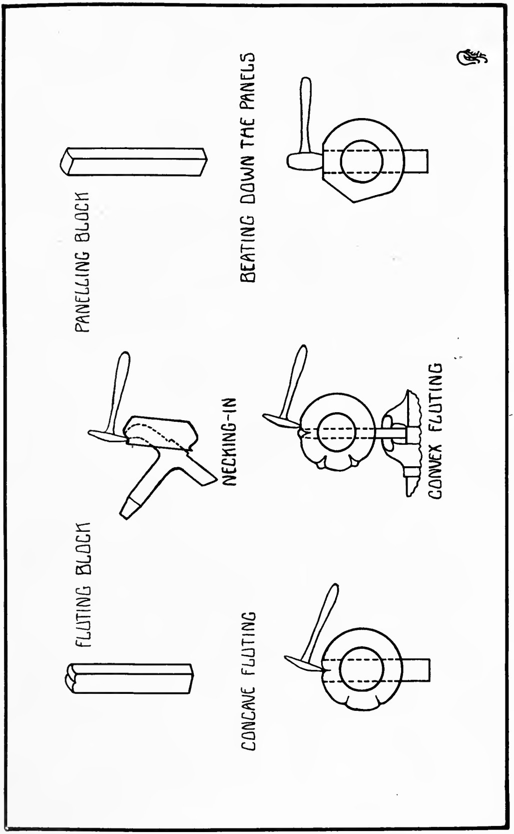

Fig. 87. Details of construction.

with the end shaped into a flute like that which is to be produced on the bowl, as shown in Fig. 87 The shaping of the wood may be done with a wood rasp and coarse file. Do not try to make the end of the fluting block exactly the shape and size of the flute in the bowl, but make it a little smaller in size and curvature. This is so that you can move the bowl around more freely when you are doing the actual fluting.

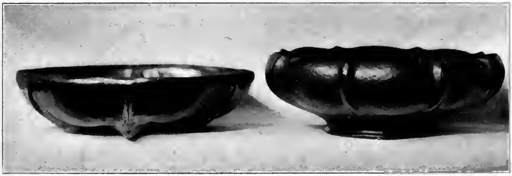

Fig. 88. Copper nut-bowls, convex fluting.

Fasten the fluting block upright in the vise with the modeled end up; place the bowl over the end of the fluting block with the vertical pencil line exactly over the flute in the block, and beat the metal down into the flute with the neck hammer, No. 7293,[11] as shown in Fig. 87. This will require considerable care and some practice to get a smooth uniform flute. If the metal gets very stiff and hard soften it by ''annealing'' as described before. When the bowl and the fluting is uniform and true it is ready for the cleaning and ''planishing'' process.

It will be found that the fluting process has a tendency to draw the top of the bowl in and make it smaller in diameter. Advantage may be taken of this fact to vary the design and get a sharp curve at the edge of the bowl that makes it more interesting.

This tendency of the fluting process to draw in the edge is something to be taken advantage of to produce a better and more characteristic bowl, and should not be taken as a restriction to hold us to a certain form, as sheet metal in the hands of a competent craftsman is manipulated with a freedom and ease which is astonishing in many respects. As an illustration of this, the second bowl, Fig. 86, was raised and fluted in the same way as the first, but the edge was hammered out, giving the section of the bowl a petal like shape.

[11]See Fig. 37, p. 85.

CONVEX FLUTING.

The flutes described above are concave flutes. There is also the convex flute, shown in the bowls in Fig. 88. This type of flute is made by placing a piece of iron or hard wood, filed to the approximate shape of the flute wanted, in the vise and placing the vertical pencil line drawn on the side of the bowl exactly over the fluting block, and then beating the metal down alternately on each side of the block with the neck hammer, as shown in Fig. 87.

PANELING.

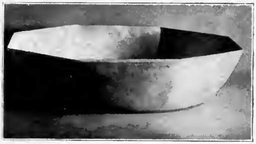

Fig. 89. Silver salad bowl, paneled.

There is still another development of this characteristic means of modifying the shape of a bowl and that is by "paneling" the sides, as shown in Fig. 89. This is done by making a paneling block, a piece of hard wood about 12″ long, a little narrower in width than the width of the panel, and about 1″ thick, and shaped with a slight curve in one direction on the end, as shown in Fig. 87. The bowl is placed on the paneling block so that the vertical pencil lines come to the edge of the block, then the metal is beaten down to the block with a smooth wooden or rawhide mallet. See Fig. 87.

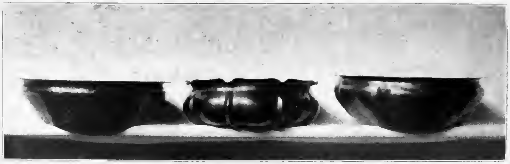

Fig. 90. Copper nut-bowls, "necked-in."

It must be remembered, when using either the concave or convex flutes or the paneling, that the bowl must be raised to shape first; then the pencil lines are drawn down the sides; then it is paneled or fluted; and afterward the bowl is cleaned and planished all over.

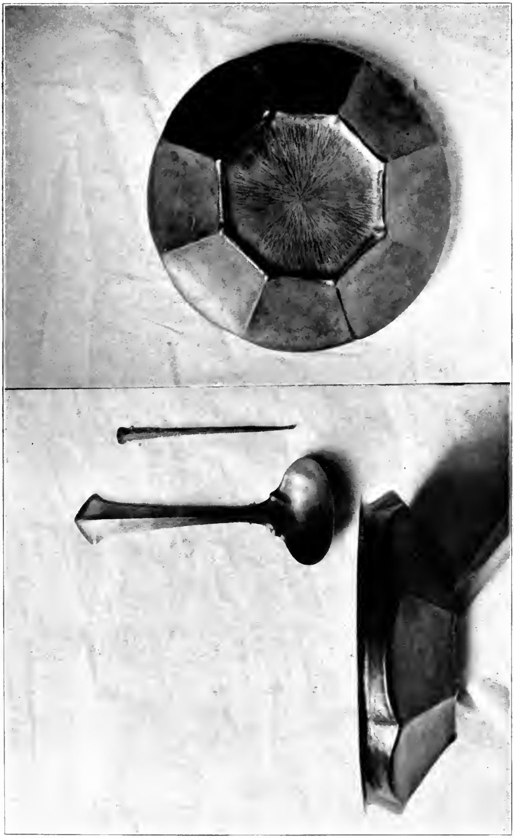

Fig. 91. Nut-bowl, spoon, and nut-pick.

NECKING IN.

The logical progression in the series of problems that we are following brings us to the interesting process of "necking in"; that is, drawing a nut-bowl, vase, jardiniere, or pitcher, in sharply near the edge making a neck. This process is best illustrated by "necking in" a nut-bowl similar to those illustrated in Fig. 90. The first is a plain bowl, the second is fluted with convex flutes, and the third is fluted with concave flutes.

Fig. 92. Jardiniere, necked-in, edge and sides fluted.

The process of necking in is similar to that of fluting, the main difference being that the neck, which is simply a continuous flute running round the bowl, is horizontal instead of vertical. To "neck in" a nut-bowl, first draw a pencil line around the bowl near the edge just where the bowl begins to change its shape into the neck. Then place the tee-stake, No. 146-A,[12] in the vise in the position shown in Fig. 87, and beat down the metal just above the pencil line. Care must be taken to strike the metal so that the neck hammer drives the metal down the side of the tool as shown in the drawing. It will be found necessary to anneal the bowl two or three times during this process.

The edge may be left flat as in the first and third bowls, Fig. 90, or it may be fluted and shaped, as in the second bowl, or the jardiniere, Fig. 92. In the latter case the order of steps is as follows: *First,* raise the bowl; *Second,* beat in the neck; *Third,* flute; *Fourth,* clean and planish; *Fifth,* color and finish.

Fig. 91, which shows the two views of the same bowl, shows the extent to which these problems may be carried. It also shows two simple problems that go naturally with a nut-bowl, namely, the nut-spoon and nut-pick.

There are five distinct methods of making a spoon by hand, and the spoon illustrated is made by the simplest process, which is to transfer the outline of the spoon to the flat piece of 18-gage metal,

[12]See Fig. 64, p. 111.

saw it out with the jeweler's saw, and beat the bowl of the spoon into shape in the hollow wooden block described before. It will be necessary to raise a flute down the handle to stiffen it, as the 18-gage metal is not strong enough if left flat, but it is plenty strong enough if it is fluted and shaped and well planished afterwards.

The nut-pick is made from a piece of round soft copper wire 3/8″ in diameter and as long as needed. The process is: heat the wire red hot, hold it by a pair of pliers on the tee-stake, and forge it into shape with hammers, then trim off the rough edges with a file.

Fig. 92 shows the extent to which this elementary raising and fluting can be carried with only a few inexpensive tools. The best way to approach these problems is to analyze the various processes and place them in order, and the problem then simplifies itself. The finished problem is valued for itself, but it cannot be compared to the benefit received by the maker in the acquired knowledge of tools and processes used in modifying a common material, the exercise of forethought and patience, the esthetic responses awakened, the necessary exercise of the imagination, the training in accurate observation, and, greatest of all, the joy of creating an object of utility and beauty.

Fig 93. Brass nut-bowl, convex fluting.

Chapter XVI.

RAISING BY COURSING, HARD SOLDERING.

In Chapters XIV and XV an illustrated description was given of the simplest method of raising a shape from the flat metal without seaming. Reference was made to three distinct methods of raising such forms. The first having been illustrated we will now proceed to a description of the second method, which is almost always used in combination with the first.

RAISING BY COURSING.

In the illustration of the two pitchers, Fig. 97, it will readily be seen that it would be impossible to raise such shapes entirely by the first method, that of beating into a hollow block from the inside, as was described for the making of bowls, etc., altho nearly one-half of the raising of the pitcher can be done by that method. Fig. 94 shows the progressive steps taken in raising the large pitcher. No. 3 is about as far as it is possible to raise the shape by means of the first method, which we will distinguish by the trade term of "beating." With No. 4 the second method, known as "coursing," is resorted to. In this method the hammering is done entirely from the outside, with a broad faced neck hammer, and the pitcher is held on the round end of a No. 11 stake in the position shown in the drawing, Fig. 94. It must be remembered that in "coursing" (as in any other case where the shape is being changed), the metal must be softened by annealing whenever it gets hard and does not yield to the blows of the hammer.

The main object in "coursing" is to hold the metal in contact with the stake at about an inch below where the hammer is striking, and at the spot where the hammer is striking to keep the metal away from the stake, and to hammer it down to the stake thus closing in the metal and making the shape narrower. This will be understood better after a study of the drawing. The hammer blows are struck in rows all around the piece of work, starting at the bottom or where the shape starts to change, each row being about ½″ higher than the preceding row until the top is reached.

It may be seen, Fig. 94, that there appears to be more metal in No. 6 than in No. 1. This apparent discrepancy is caused by the

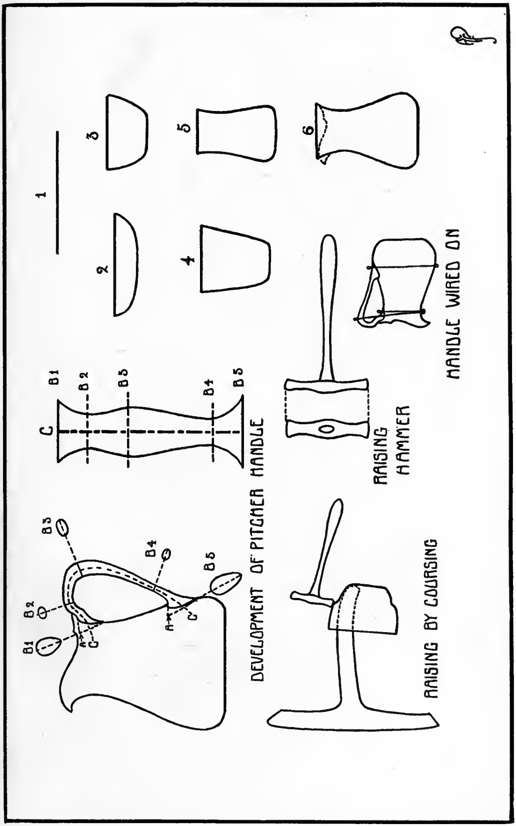

Fig. 94. Details of construction.

fact that the metal stretches and expands under the blows of the hammer. The mount of expansion is governed by so many factors that it is impossible to state it by any exact rule, but the approximate amount may be illustrated by the hollow handled pitcher, Fig. 97. It is 7″ high and 5½″ across the base, which dimensions added together give a total of 19½″ from one edge of the metal to the other. The pitcher was raised from a circular disk of metal 14″ in diameter. This shows that the metal stretched 5½″.

The neck of the small pitcher was formed by the "necking in" process illustrated on the bowls and jardineres in Chapter XV.

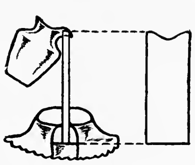

Fig. 95. Lipping a pitcher.

Fig. 96. Bellying hammer.

The lips of the pitchers may be easily formed by cutting the shape of the lip in the edge of a ¾″ board, fastening the board in the vise, and beating the metal down into the wooden lip with the neck hammer, Fig. 95.

After the pitcher or any other similar vessel is raised to nearly the desired form, it is often found necessary or desirable to drive out some part from the inside. This can readily be done by means of a tool that is known in the trade as a "bellying hammer," which is really not a hammer at all, but a piece of ½″ round iron or steel slightly headed up at one end, bent into shape, with a file handle placed on the other end. The shape of this tool, and the method of using it, are shown in Fig. 96.

Another tool that is sometimes used for the same purpose is the "snarling iron," which is a piece of ½″ round iron or steel about 16″ long with about 2″ at each end bent over at right angles in opposite directions. One end is fastened in the vise and the other end held firmly inside the pitcher against the spot that it is desired to drive outward, and a sharp blow is struck with the hammer on top of the snarling iron about 2″ from the vise. This will cause the snarling iron to jump, and in springing back it will strike a

Fig. 97. Pitcher with wire handle; fluted pitcher with one-piece hollow handle.

sharp blow on the inside thus forcing out the metal. The shape of the "snarling iron," and the method of using, are shown in Fig. 98.

MAKING THE HANDLES.

Three distinct types of handles are shown in the illustrations. The handle of the small pitcher in Fig. 97 was made by heating a piece of 1/4" round wire red hot and hammering and forging it into the desired shape, filing it true afterwards. It might be well to state here that copper can be forged, hammered, and bent while

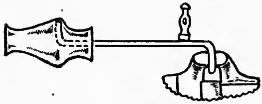

Fig. 98. Snarling iron.

it is hot, but that brass cannot, as it will break and crumble under the blows of a hammer.

The handle of the fluted pitcher, Fig. 100, was cut out of a flat piece of 18-gage metal; the edges were lapped as described for the edges of plates and book-ends, and then bent into shape and soldered on to the pitcher. The handle of the large pitcher, Fig. 97, and the handles of the silver pitcher and of the salad bowl, Figs. 105 and 108, are hollow and are the most difficult kind to make. The handles of the salad bowl are made of two pieces, the curved inside part of the handle being one piece and the flat outside piece being soldered on after the curved piece has been hammered into shape.

The handle of the large pitcher, Fig. 97, is made of one piece of flat metal. The method of making a hollow handle out of flat metal is as follows: Make a full size outline drawing of the handle, as it is to fit on to the pitcher, and sketch in the extra length on the ends as is shown by the dotted lines on the large drawings at A, Fig. 94. Next mark on the drawing the places where the handle varies in section and draw the shape of the sections as shown at B. Next draw the dotted line C thru the middle of the handle and measure its length by spacing off with dividers or by bending a piece of wire to the shape of the line. Lay off this length, as at C, and mark the distances from the ends where the sections B were taken. Obtain the circumference of the B sections, and lay off one-half of the circumference on each side of the corresponding section on the straight line C. Connect the ends of these lines with a freehand curve and you will have an approximate pattern of the hollow handle ready to be cut out of the flat metal. It is bent into shape by hammering with the neck hammer over a hollow

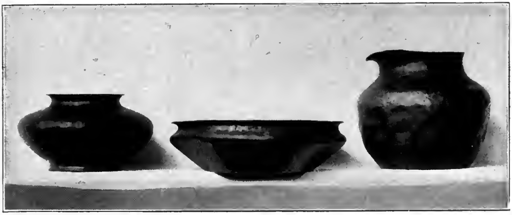

Fig. 99. Tea-pot body, jardiniere, pitcher, roughly raised to shape, ready for the handle and spout to be soldered on.

in a block of wood, making the edges curl in towards each other, then driving them together from the outside until they touch the full length of the handle, when they should be hard soldered together. Then the handle should be filled with melted rosin or

Fig. 100. Pitcher with flat handle and bowl.

burgundy pitch and when the rosin is cold and hard the handle may be bent into shape with a mallet over the tee-stake and hammered smooth and the rosin melted out. It should next be fitted to the body of the pitcher and wired on as shown in the drawing, Fig. 94, then hard soldered into place.

HARD SOLDERING.

The handles and spouts on such objects as kettles, tea-pots, and pitchers, are usually soldered into place with hard silver solder, and should seldom be riveted, or soldered with soft solder. There are many formulas for making hard or silver solder, but that which

Fig. 101. Silver pitcher and sugar bowl, with forged wire handles.

is best for our purpose is composed approximately of silver 8 parts, copper 3 parts, spelter (zinc) 1 part. This makes an easy flowing solder for copper and brass. A fair solder for this work may be made by melting together 2 parts of silver and 1 part of high brass. Brass is made of copper and zinc, high brass having a larger percentage of zinc than low brass. Melt together on a piece of charcoal or asbestos, it will run into a ball, and while it is still melted quickly place a flat piece of iron on it; this will flatten it out so that it may be cut into small pieces more readily.

The place where the handle or spout is to be soldered on must always be planished before the handle is tied on, because it would be very difficult to planish it after the handle is soldered on.

Hard soldering on copper and brass is easily done if these three points are observed: The joint to be soldered must be filed clean; every part of the joint and every bit of the solder must have borax on it; the work must be made red hot to cause the solder to run into the joint. The borax mentioned is the powdered borax that can be obtained at any drug store. It must be mixed with water to the consistency of cream and applied to the joint with a small brush. The handle is tied on with fine iron wire, Fig. 94. The solder is cut into very small chips and placed at the joint and the heat is applied slowly until the borax is dry; then apply the full power of the blow-pipe until the solder melts and runs into the joint.

To clean the pitcher and to remove the melted borax place it for about thirty minutes in a "pickle" made up of one part sulphuric acid and two parts water. Clean it with the wire brush or emery cloth, planish smoothly all over, then color and wax as described before.

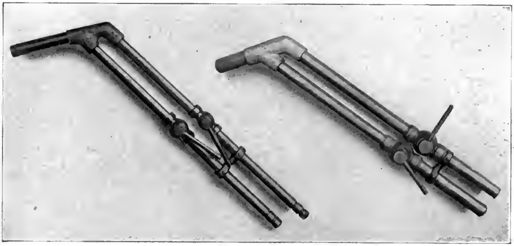

Fig. 102. Blow-pipe. No. 8c. Fig. 103. Blow-pipe. No. 8e.

For hard soldering, annealing, and melting such as we would do in making the problems in the series, there is nothing better than the 8C blow-pipe for small work, Fig. 102, and the 8E blow-pipe for the larger work, Fig. 103. Both blow-pipes are to be used in combination with the 10A foot blower, Fig. 104. If power is convenient, and more than one blow-pipe is to be operated at one time,

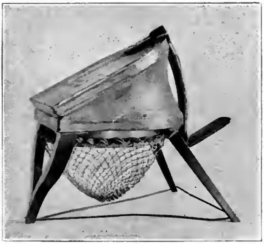

Fig. 104. 10A Foot blower.

a power blower is best. If no gas is available, a 40c gas generator is very good, or a plumber's blow-torch may be used for small work. If a large soft flame is desired an O-L No. 82 blow-torch is best and for a sharp needle flame O-L No. 29.

Figs. 105, 106, and 107 show a number of solid silver cream pitchers, sugar-bowls, and salt-dishes. While most of the problems described in this series have been made of copper and brass, the instructions given would be the same for making the same objects

Fig. 105. Solid silver pitcher, one-piece hollow handle.
From Kalo Shop, Chicago.

in silver, with this important exception, that the annealing of silver should be done in a rather dark place so that it can easily be seen when it becomes red hot, and it should never be heated to more than a dull red or it will be very liable to melt. Silver melts at 1830 degrees Fahrenheit, and copper at 1995 degrees, so it will be seen that the melting point of silver is considerably lower than that of copper.

The feet on the salt-dishes were made by melting scrap silver into little balls on a charcoal block; it is a peculiarity of metals that if a small quantity is melted on a flat surface, it will run together in the form of a ball. Three balls of equal size were made and soldered with the silver solder to the bottoms of the dishes, thus forming the feet.

Silver articles may be oxidized with the same sulphide of potassium solution that was suggested for use on copper. See p. 41.

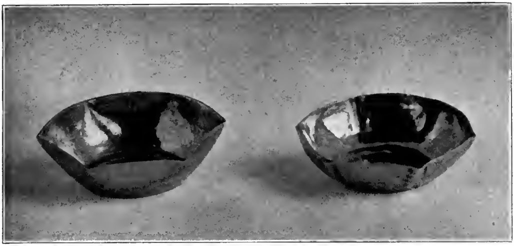

Fig. 106. "Paneled" silver salt dishes.

To etch a design on silver proceed as with copper, except that the etching solution is made of nitric acid, 20 parts; hydrochloric

Fig. 107. Silver sugar-bowls, fluted and paneled, wire handles.

acid, 5 parts; water, 75 parts. Or, a solution of equal parts of nitric acid and water may be used.

Articles made of silver may be polished by hand by first using fine emery cloth. Then mix a paste of flour emery or powdered pumice with oil, and apply with the piece of emery cloth. Nearly all metals under certain conditions will form a combination with the oxygen in the air. Iron rusts, forming oxide of iron; copper when heated red hot forms a black scale which peels off when it gets cold, this is black oxide of copper. Silver when it is heated to redness also forms a thin white scale (designated in the trade as "fire scale"), that clings tenaciously to it. In fact, whenever it is desired to remove it, it is necessary to file, scrape, or polish it off, or else remove it with acid. The reasons for mentioning it here are: *First,* when soldering two pieces of silver together, both pieces should always be filed so as to cut thru this fire scale, otherwise

Fig. 108. Silver salad-bowl, with two-piece handle.
From Kalo Shop, Chicago.

they are very liable to break apart; *Second,* when polishing a finished piece of silver one is very liable to polish thru the fire scale, and as the fire scale is of a different shade of color from the silver underneath, it makes the object look patchy in color. So it is necessary either to have all the fire scale off, or else have it all on. The old craftsmen left it all on. The modern manufacturers take it all off by dipping it in a solution composed of equal parts of nitric acid and water, to which is added a small quantity of acetic acid (one-half pint acetic acid to two gallons of the compound) to make it work smoothly. For our work it is just as well and very much easier to leave it all on, so after the silver has been well polished and all the scratches and marks removed, heat it with the blow-pipe to a dull red, and when it is nearly cold place it in the sulphuric acid ''pickle'' and leave it there for ten minutes, then repeat the process, and the silver will be a dull white (care must be taken not to put any iron or steel in the pickle, as it will turn the silver copper color). Then it should be polished lightly with the emery paste, washed off in hot water with soap, and finally polished with canton flannel and powdered rouge or whiting.

This treatment will give to the silver the soft, dull sheen that has added so much to the charm of the old colonial silver, and which is so much more beautiful than the hard, bright glitter of the modern commercial finishes.

The aluminum bread-tray, Fig. 109, was beaten up from a flat piece of metal by methods similar to those described for working copper, except that it is not necessary to anneal aluminum.

Aluminum can be cleaned by immersion in a solution of caustic soda.

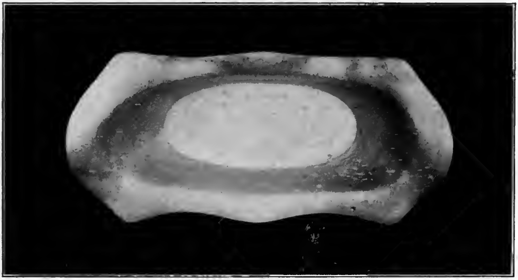

Fig. 109. Aluminum bread-tray.

Chapter XVII.

RAISING BY WRINKLING, SEAMING.

In chapters XIV and XV instructions were given for "raising" bowls and other forms by the simplest method—beating into a hollow in a block. The second method, raising by "coursing," was presented in chapter XVI. The third method, raising by "wrinkling," is now to be taken up. This is the fastest method of raising any large and deep object, such as a vase, without seaming. This is a fast method, but at the same time it requires considerable practice and a higher degree of skill than the other methods.

Fig. 110 shows a piece of work that has been "wrinkled" for the first hammering, with the hammer and the wrinkling block used in the process. The steps taken are as follows: Cut out a piece of metal, 18-gage, the size and shape required, and with the pencil compass mark a circle the size of the base. In this case a circular

Fig. 110. Hammer and block used in wrinkling, and piece of work showing the first step.

piece of metal was used, but the method is the same for square or oval objects. Get a piece of hard wood, about 2″x2″x8″, and make a wrinkling block of it by filing a crease in the end, as shown in Fig. 110. Place the block in the vise and with the thin neck hammer shown beat the metal into the crease. There are two points to be careful of: the first one is to allow the metal to bend in freely when hammering the wrinkles; that is, do not try to stretch the metal when driving it into the wrinkling block. The second point is to be sure to have the wrinkles evenly spaced and straight.

The next step is to beat down the wrinkles with a raising hammer, holding the piece of work upon a tee-stake the same as when "raising by coursing."[13] By looking closely at the right-hand side of the piece of work shown in Fig. 110, it can be seen where the first course has been started. Care must be taken not to allow the wrinkles to fold over when beating them down, as this would result in the metal cracking. When the metal gets hard and stiff, soften it by "annealing" as described before.

Fig. 111. Unfinished vase nine inches high, raised by the "wrinkling process."

Fig. 111 shows an unfinished vase, 9″ high, that was raised entirely by the "wrinkling process." It will be seen, however, that the coursing process will have to be used to carry it to completion.

Figs. 112 and 113 show other vases raised into shape from a flat circular disk by the same methods.

The three kettles, Figs. 114, 115, 117, were raised into shape by the same methods, the patterns for the spouts and handles being drawn and laid out in the manner described for hollow pitcher handles, and soldered on to the body with silver solder. The knobs on the covers are hollow, being part of the cover hammered out to form the knob.

Art metalwork divides itself into four large divisions, namely: flat work, such as the paper knife; bent and riveted work, such as the clock and the lantern; raised work, such as bowls and vases; seamed work, such as pitchers and vases that are not beaten up

[13]See Fig. 94, p. 133.

Fig. 112. Copper vase raised from flat piece of metal.

Fig. 113. Copper vase raised from flat piece of metal.

Fig. 114. Kettle.

Fig. 115. Kettle and tray.

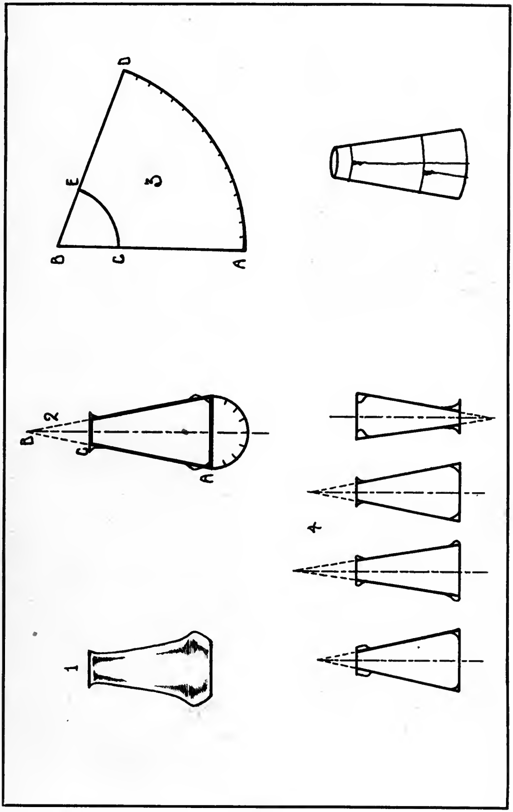

Fig. 116. Method of obtaining pattern for seamed and fluted vase.

from a flat disk, but have a seam or joint that is soldered together with silver solder. It is this last division, "seamed work," that we are now to deal with.

SEAMING.

We will take the seamed and fluted vase, Fig. 118, for a description of the simplest kind of seamed work. It is first necessary to obtain a pattern that will, when it is cut out of metal and the seam soldered together, be the approximate size and form of the vase that is to be made. The method of obtaining this pattern is shown in Fig. 116. We must first have an accurately drawn outline of the size and shape of the finished vase, as shown at 1, Fig. 116. It will be noticed that the vase approximates in shape the form of a cone. We can easily develop a pattern of a cone, so we proceed as tho the vase were a cone, as at 2. It can readily be seen that if we can obtain a cone of metal the shape of the heavy lines, it will be a comparatively simple matter to hammer out the top and hammer in the bottom, to produce the form of the vase.

Fig. 117. Kettle.

Fig. 118. Seamed and fluted vase.

To obtain the pattern of the flat piece of metal that will roll up into a cone of the desired shape and size, proceed as follows: Extend the general lines of the vase in a straight line upward until they meet at B. In extending these lines, disregard any slight curves, as may be seen in the sketch. The heavy lines show the cone desired. Draw a half circle the size of the base of the cone, and divide it into eight equal parts. Lay off the line A-B, as shown in 3, also the distance C-B. Draw an arc with A-B as the radius, and another with B-C as the radius. With the dividers carefully measure one of the eight equal parts of the half circle drawn at the base of 2, and lay off the distance sixteen times on the arc A-D, in 3. Where the sixteenth space ends, draw the line D-B. The space enclosed by A-D, D-E, E-C, C-A is the pattern that will roll up into the cone desired.

Fig. 119. Seamed vases.

Patterns may be developed in the same way for any vase or pitcher form. A few suggestions are given at 4.

To make the vase, first cut a piece of metal (copper, brass, or silver) the size and shape of the pattern, and prepare the edges of the seam for soldering by striking them with a file, thus making them rough so that the solder will hold the seam firmly. Roll the metal so that the edges come together, being sure that they fit perfectly, and hold them in place by binding them together with soft iron wire, in the manner shown in Fig. 116. The vase is now ready for soldering with silver solder by the method described in chapter XVI.

After it is soldered and has been cleaned by "pickling" in the sulphuric acid solution, it should be made true and round with a mallet on a tee-stake, and the top should be hammered out and the bottom beaten in to conform to the outline desired. It will probably be necessary to soften it by "annealing" during this process; if so, care must be taken not to get the seam so hot that the solder will melt. After it has been brought to the desired shape, the bottom edge should be filed flat and a piece of metal the right size soldered on for the bottom.

PLANISHING WITH A CORE OF PITCH.

The vase is now ready for "planishing." It would be rather difficult to planish a vase such as the one illustrated by the method previously described (Chapter XII). In the first place, it would be no easy matter to find a tool that would go inside the vase and fit the various curves, and it would also be difficult to hold the vase on the tool in the proper position to do good planishing. We avoid these difficulties by filling the vase with pitch, allowing it to harden, and planishing on the pitch. The pitch mixture is made up of equal parts of Burgundy pitch and plaster of Paris measured by bulk. The Burgundy pitch should be melted first in a common saucepan and the plaster of Paris stirred in slowly. Be careful that the pitch does not take fire. When the pitch and plaster are thoroly mixed, pour into the vase and allow it to get hard. Then the vase may be planished, and if it is desired it may be fluted as shown, Fig. 118.

This fluting is done in the same manner and with the same tools as described for the process of "chasing," Chapter XIV, except that the tool is a little thicker and blunter, and instead of being done on a board, the fluting is done while the vase is full of pitch. If the fluting is to be rather deep, it is advisable to do the work while the pitch is slightly warm.

After the vase is planished smooth, the pitch may be melted out by tying some wire around the vase, suspending it bottom upwards, and turning the flame from the blowpipe on the pitch at the mouth of the vase. Do not turn the flame on any part of the vase except where the pitch is exposed to the heat, as it would be likely to explode if

Fig. 120. Seamed silver pitcher. *From Kalo Shop, Chicago.*

the pitch in the upper part got melted first and could not get out easily.

The silver pitcher, Fig. 120, was made by the seaming method, as described in this chapter, excepting that it was planished on a stake, the mouth of the pitcher being wider than those of the vases. The handle of the pitcher is made of thick flat silver bent and filed to shape. The wire around the mouth is half-round wire soldered on.

The question frequently arises as to the commercial value of the kind of work described in this book. The answer to this question, of course, depends entirely upon the design, and the care with which the object is made and finished. A value is placed upon a piece that is of good design, well made, and carefully finished, in the same way that a value is placed upon a fine picture or any other work of art. It is not valued by weight of metal or the time it took to make it, but as a piece of art work. If a piece is of poor design, crudely made, and carelessly finished, it is worth nine cents a pound, because that is the market price of scrap copper and brass.

The work used to illustrate this series is, with a few exceptions, the work of students, and it will give some idea of the commercial value of such work if the prices at which they were sold, or are held at, are known. The price of the kettle shown in Fig. 114 was \$35.00; of the seamed and fluted vase, Fig. 118, \$25.00; of the three seamed vases, Fig. 119, \$8.00, \$18.00, and \$12.00, respectively.

But the commercial value of the work is not to be compared with the value gained by the student in recognizing and controlling the many factors that make for success—the new experiences and knowledge accumulated—the gain in appreciation and, best of all, the joy of creating.

Chapter XVIII.

CRAMP SEAMING, REPOUSSE, RECESS CHASING.

In chapter XVII the method of making a seamed vase was described. That method of "plain seaming" is perfectly satisfactory for a vase that is not to have its general shape changed very much from the lines that it had when it was seamed. But that

Fig. 121. Seamed silver pitcher.
From Kalo Shop, Chicago.

method of seaming would not work satisfactorily with the pitcher shown in Fig. 121, or the vase shown in Fig. 122, because the top and bottom in each case have been hammered out so far that if it had been made with a plain seam, the seam would certainly have broken.

To avoid that serious difficulty, we make use of a slightly different kind of a seam. This type of seaming was known among the old English metalworkers by the name of "cramp seaming." On every piece of genuine old English metalwork, and on kettles particularly, one can readily find the characteristic zigzag mark of this seam. On the vase in Fig. 123 the seam has been soldered with silver solder, and is easily distinguished.

Fig. 122. Vase with "cramped" seam. This vase could not have been made by the method of plain seaming.

Fig. 123. "Cramped" seam vase ready for shaping.

This kind of seam is readily understood and is easily made, the method being as follows: After the pattern has been developed, and the metal cut out, as described in chapter XVII, a line is drawn with compass or dividers parallel to each edge of the seam. These two lines must be drawn on opposite sides of the piece of metal, and may vary from ¼″ to ¾″ from the edge of the metal, depending, of course, upon the size of the vase. Then, with a coarse flat file, thin down the edge to the line that was drawn parallel to the edge. The foregoing directions are illustrated at 1 in the drawing,

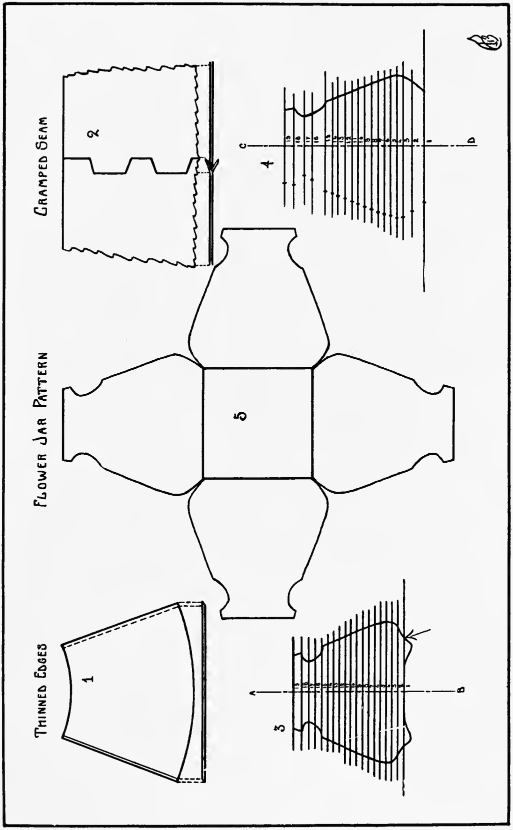

Fig. 124. Details of construction.

Fig. 124. The thickness of the metal is much exaggerated so as to show more easily the way in which the edge must be filed down. The next step is to lay off along the entire length of one edge spaces about ½″ apart, and with a pair of shears cut down to the line that was drawn parallel to the edge. The next step is to bend each alternate piece of metal up and the other piece down. Bend them with a pair of pliers just enough to allow the other edge to slip in between when it is bent around, thus bringing the edges of the seam together. These directions are illustrated in the sketch at 2. The next step is to bend the metal around so that the two edges are together, and slip the edge that has been filed thin, but not cut, between the small pieces or "cramps" that have been bent up and down. Hold the edges firmly together and place the vase over a round stake, and with a rawhide or a wooden mallet hammer the cramps down. Next bind the edges together with wire, and solder with silver solder. The vase is now ready for shaping and fluting.

Fig. 125. Showing extent to which a cramped seam will stretch.

The extent to which this kind of seam can be beaten out is shown in Fig. 125. The vase is 14″ high and, as shown in Fig. 123, the bottom measured 4¾″ across; as shown in Fig. 125, the bottom has been hammered and stretched out until it measured 7¾″ across. The vase was fluted in the same manner as shown for nut-bowls, and the bottom was "lapped" on as shown for candlestick bases. (See Chapters XV and XI.) To make the bottom water-tight, the bottom edge of the vase was coated with soft solder applied with a soldering iron. Then the bottom was "lapped" on, and finally the lapped seam was held in the flame of a Bunsen burner, melting the solder and making the vase water-tight. The vase was then polished with emery cloth, colored dark with potassium sulphide solution, the finish was relieved with emery cloth, and finally the vase was given two coats of wax.

SEAMING, SQUARE CORNERS.

There is one other method of making a shape that cannot be made by any of the methods previously described, and that is the method used in making the flower jar shown in Fig. 126. This piece is square, with sharp corners, and it would be very difficult,

Fig. 126. Flower vase seamed at corners. "Chased" decoration.

if not impossible, to make it by any of the previously described methods. So a pattern is developed from a drawing, and laid out on a flat piece of metal; the metal is cut to the pattern, the four sides are bent to the shape of the original drawing, and the corners are soldered together with silver solder. The white silver solder may be seen on the corners of the jar, as the jar was not polished or colored when the photograph was taken.

Fig 127. Lamp with "cramped" seam base.

The details of this method of pattern development are as follows: First, draw an accurate full-size outline of the desired shape, as shown at 3, Fig. 124, and draw the center line A-B. Carefully divide the center line into 1/4" spaces with the pencil dividers, and draw lines clear across the drawing on the 1/4" points. Ignore the feet, as they can easily be beaten out when the shape is finished. Starting at the bottom, number the lines 1, 2, 3, etc., as shown in the sketch. Next, draw a new center line C-D, as at 4. With the pencil dividers, carefully measure the distance on sketch 3 from the point where the line 1 intersects the outline (where the arrow mark is) to the point where line No. 2 intersects the outline. Lay this distance off on the new center line C-D, and number the points 1 and 2, respectively. Continue with the remainder of the points, remembering always to measure the distance on the outside line of sketch No. 3 and to lay it off on the center line C-D of the sketch No. 4, being sure to number them as you lay them off. This work must be done accurately or the vase will not be the shape desired. When the transference of points is completed, there will be on the new center line the same number of points as on the old center line, but they will not be equally spaced. The next step is to place one leg of the dividers at the point where the center line and line No. 1 intersect on the No. 3 sketch, and measure the distance to where the same line intersects the outside line (where the arrow mark is). Lay this distance off on both sides on line No. 1 on the No. 4 sketch. Do the same thing with all the other lines, and the result will be a series of points the same as on the left side of the No. 4 sketch. Connect these points, as on the right side, and you will have a pattern of one side that when bent to shape will be the shape and size of the original sketch. With a piece of transparent tracing paper copy the outline of the pattern of the side, and then lay off a square the size of the bottom of the flower jar and transfer the pattern of the side to each of the four sides of the square bottom, as shown in sketch No. 5, and you will have a completed pattern of the flower jar.

Stick the pattern on to a flat piece of 18-gage copper, or transfer it to the copper with carbon paper, and cut or saw the metal to the same shape as the pattern. Carefully file the edges to the correct shape and also file them to a bevel so that they will fit together at the corners. Bend each side upward and inward until the corners come together, then solder with silver solder the four corners as far as they fit together, then bend each side upward and inward a little more and solder again, continuing this process until the top is reached. Remember to keep the seams clean and free from dirt or grease of any kind; it is best to cover the entire length of each seam with borax, which will keep it clean, and also protect it from oxidation.

After it has been "pickled" and cleaned, if it is to be left plain it is ready for "planishing." In such a complicated shape it will probably be advisable to fill it with pitch and planish the metal smooth on the pitch after it has become hard. This method of planishing was described in chapter XVII.

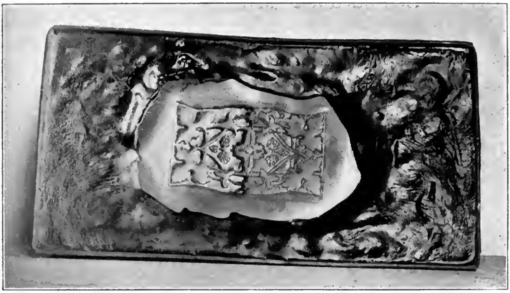

Fig. 128. First process in chasing; The right-hand side shows the student's first attempt.

Fig. 129. Chased copper plate, showing an application of the method of beating down the background with the planisher chasing tools.

Fig. 130. Chased blotter, in which the background was beaten down from the front, and also the design beaten up from the back.

CHASING.

Repoussé and chasing are synonymous terms for the same kind of work and process. Repoussé is the French term, and chasing and chased work are the English terms. As the term chasing is that which is in common use in the trade, and in the supply catalogs the tools are designated as chasing tools, it seems best in this book to use that term.

Fig. 131. Silver cup, flat chasing, showing the extent to which simple chasing may be carried.

In chapter XIV instructions were given for the most elementary method of chasing—that is, chasing on a piece of soft wood instead of pitch. Chasing is sculpture in metal; it is the fine art of metalworking; it is the making of bas reliefs in metal, and it requires training and ability to see and think in three dimensions. Saw-piercing and engraving require only two dimensions, length and breadth; chasing requires the third, thickness.

An explanation of the technical processes of chasing is very simple and is easily understood. The metal with the design drawn on it is embedded in chaser's pitch, and the design is outlined with a chisel-like tool called a "tracer." The metal is then removed from the pitch, placed face downward on a piece of soft wood, and the raised parts of the design are beaten up from the back. The metal is then "annealed" and placed back in the pitch. The design is then modeled into shape with the proper tools.

The chasing tools used are made of tool steel 1/8″ or 3/16″ square

Fig. 132. Chased flower jar, "traced and snarled." This photograph shows the preliminary steps in the work, which is shown completed in Fig. 126.

and 4″ long. A well selected set of 50 chasing tools may be bought from a dealer in such tools for $7.50. But it would be just as well for a beginner to buy a straight and a curved tracer, a large and a small planisher, learn to use them, and make the others as he needs them. When making them, after they have been filed to shape, they must be hardened by heating the points red-hot and plunging in cold water. They are then polished bright with emery cloth and tempered by slowly heating them to a dark straw color and again plunging into water. Chasing tools may be roughly divided into four large divisions: tracers, straight and curved, that are used to make lines; planishers, of numerous shapes and sizes, used to beat down the background and for modeling; matts, similar in shape to the planishers, but with matted or grained surfaces which are transferred to the metal when the tools are used; beads, rosettes, and special tools that are not of any great value to the beginner. A box of chaser's tools is shown in Fig. 134.

Chaser's pitch is made of equal parts Burgundy pitch and plaster of Paris melted together. To every 5 pounds of combined pitch and plaster add a piece of tallow the size of an English walnut. Melt the pitch first, and slowly add the plaster, stirring it in as you add it to the pitch.

Fig. 133. Chased flower jar, background beaten down. A later stage in the process.

For large flat pieces the pitch may be poured into a square cake tin, or an ordinary bread tin. For small, fine work it is better to use the round pitch block and ring, shown in Fig. 134. A cheap pitch block can be made from an ordinary pudding pan about 6″ or 8″ in diameter. The bottom should be beaten out round, so that it will set firmly in the ring and be readily turned and tilted when necessary.

A chaser's ring is a ring that holds the pitch block in position while the piece is being chased. A very satisfactory one may be made by taking a piece of copper 2″ wide and about 20″ long and riveting or soldering the ends together so as to form a circle. Then

Fig. 134. Chasing on pitch. Pitch block, chasers ring, tools, and method of holding tool.

wind around this ring strips of cloth until the pitch block fits in snug and tight, as is shown in Fig. 134.

After the design is drawn or transferred on to the metal, the edges of the metal should be turned under with a pair of pliers, and then placed on top of the pitch and warmed with the flame of the blowpipe or Bunsen burner. The heated metal will slowly sink into the pitch. Care must be taken that the metal is not too hot, as it is likely to sink in too far. When the metal is cold, start to chase the outline with the tracers. Be careful to hold the tool in

Fig. 135. Chased cover, with stone set in center.

the position shown in Fig. 134, with the fourth and third fingers resting on the metal, the second and first fingers and the thumb holding the tool. Do not hold the tool perfectly straight, but tilt the top slightly away from the direction in which you want to move.

The first attempt at tracing may be a failure, but after an hour's practice control will be acquired. The right-hand side of Fig. 128 shows a student's first attempt at tracing. Fig. 131, a silver prize cup, shows the extent to which simple tracing can be carried.

The left-hand side of Fig. 128 shows the next step, which is beating down the background with the planisher chasing tools. This is sometimes done instead of beating up the design from the back. An application of this method is shown in Fig. 129, a chased copper plate. But in the case of the blotter, Fig. 130, both methods were used. After the planishing of the background, the metal was removed from the pitch by warming it slightly and lifting it out with a piece of wire. It was then annealed and the design beaten up from the back on a soft piece of wood, set back in the pitch, and modeled to form with the small planishers. If the design is beaten up very high, it will be necessary to fill the high places with pitch before setting back in the pitch pan, as the air is likely to become enclosed in the high places and the metal will sink when an attempt is made to chase it.

The chasing on the flower jar, Fig. 126, is also a student's first attempt at chasing. Figs. 132 and 133 show the earlier steps on the same piece. To raise the design on pieces like this it is necessary to use the "snarling iron."[14]

Fig. 136. "Recess chasing Copper vase.

RECESS CHASING.

Fig. 136 shows a slightly different type of chasing that is comparatively easy of execution. It is known as "recess" chasing. The rings that run clear around the vase are simply two lines close together, made with a "tracing" tool. The outline of the decoration in the middle of the lower band was first outlined with the tracing tool and then parts of it were beaten down with a planisher lower than the level of the surface, making a recess that forms an effective and simple decoration.

The holy water font, Fig. 137, is an effective application of various kinds of chasing. The front and the small rosettes show a consistent use of raised relief chasing. The chased line connecting the rivets is made with the straight tracing tool, and the differ-

[14]See Fig. 98, p. 136.

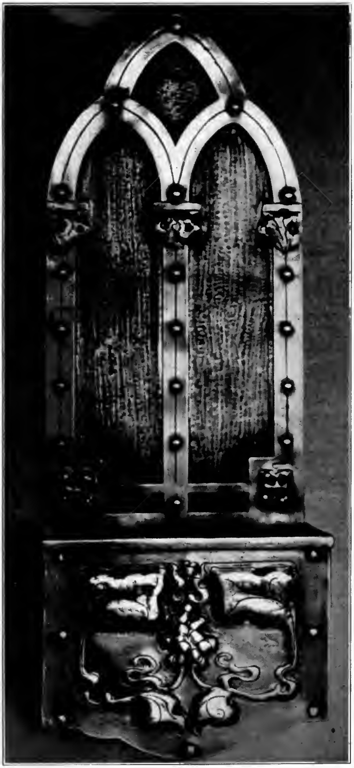

Fig 137. Font with chased decoration.

Fig. 138. Silver fruit-dish, chased carnations.

Fig. 139. Silver salt dishes and spoons.

ent texture on the background is made with a planishing tool, making a soft contrast that sets off the entire design.

The silver fruit-dish with the chased carnations, Fig. 138, is a fair example of the extent to which this interesting process can be carried. But it should be remembered by the beginner that such results cannot be accomplished by a few hours' practice. Chasing is the highest type of metalworking, and it requires and reveals the spirit of patient skill and intense interest as no other process does. It is (as always) best to start on the simpler forms first, get acquainted with and acquire a mastery of the tools and their capabilities, gradually working up to the more difficult forms, and the result will be sure and satisfying.

The three silver salt-dishes, Fig. 139, show varying adaptations of some of the processes previously described. All three have ball feet made of scraps of silver melted on a piece of charcoal or asbestos.

The first one was "paneled" on a block of wood, as described elsewhere. The applied ornament is a piece of silver wire bent into shape and soldered on.

The decoration on the center one was made with two chasing tools and a small file. The recessed oval spot is simply the impression of a "planisher" chasing tool. The small vertical line is the impression of a small "tracer." The line at the top and bottom of the ornament was filed in with a small fine file.

The third dish shows the possibilities of "convex fluting" on small work. These dishes were made from disks of silver 2″ in diameter.

The salt-spoons are 2¼″ long. The decoration of the handles was saw-pierced.

Chapter XIX.

ENAMELING.

Enameling is a process the technical explanation of which is easily given and readily understood, and at the same time it is a process that taxes the patience and artistic skill of the experienced worker; but the result in its finished perfection of line, tone, and color is one that fully repays the necessary expenditure of time and patience.

Enamel is simply a silicate glass colored with various metallic oxides that is melted on to the metal, sometimes directly on to the surface, but more often into a depression or cell prepared to receive it. There are four distinct types of enamel work: the ''cloisonne,'' ''champleve,'' sometimes called ''basse-taille,'' relief and repoussé enamel; plique-a-jour, or open-cell enamel; painted or ''limoges'' enamel. The most common is the cloisonne, which the Japanese have made so popular in this country. This is probably the oldest form of enameling, the ancient Egyptians, Greeks, and Romans having practiced it many years before Christ. The Byzantines were noted for their splendid cloisonne work in the fourth century. The most famous piece of cloisonne enameling in the world is the well-known Alfred jewel that was made by order of King Alfred the Great, and was dug up at Athelney, England, where Alfred during his lifetime established a monastery.

The cloisonne, enclosed, or cell enamel work is made by drawing a design on a piece of metal and bending soft pieces of wire or thin flat strips of metal to the outline of the design and soldering them on to the metal with hard solder, thus forming a series of enclosures or cells into which the ground enamel is placed and melted. The illustration of Japanese cloisonne work, Fig. 140, shows the steps in the process. The first is a piece of copper with the design drawn on; the second has the design worked out in thin soft brass and soldered into place with silver solder; the third has the first coat of enamel fused on; the fourth has the second coat in place; the fifth is turned over to show the back. It is sometimes necessary in large flat pieces to melt enamel on the back; this is to do away with any danger of the enamel cracking from

Fig. 140. Steps in process of "cloisonne" enameling.

the unequal tension if the enamel was on one side only. If the enamel is in small cells and on thick metal, this precaution is not necessary. In this case the cells on the back have been roughly formed by soldering on a number of spirals without any attempt at a design. The sixth enample, Fig. 140, shows the finished piece with the cells full and ground off level with the carborundum stone, and fired again to get the gloss finish. On the small pieces "cloisonne" is not a difficult process, but care must be taken to use as little solder as possible, as the zinc in the solder volatilizes with the successive firings of the enamel, the gas oozing thru the enamel, leaving holes that are oftentimes difficult to fill satisfactorily.

Fig. 141. "Champleve" enameling; etched cells ready for the enamel.

The "Plique-a-jour," open cell, or transparent enamelwork is made by building up a design of flat strips of metal without any back. The cells must be small enough to hold the enamel in place by capillary attraction while it is wet. The piece is fired in a muffle. This type is very difficult to make, but it gives a very beautiful result. The design is outlined by the strips of metal with the light coming thru the enamel giving beautiful tones and graduations of color where the enamel is thick or thin.

The "Limoges" or "painted enamel" is another rather difficult type of enamel work. The metal plate for this work is curved convexly in the center to give it stiffness. A coat of black, white, or transparent enamel is melted all over the surface. The design is then painted on with vitrifiable colors, fired again, and finally covered over with a thin, smooth coat of transparent enamel.

The "Champleve" enamel, with its various modifications of "basse-taille," relief, or repoussé, is the easiest and best type of enameling for the average worker to begin with. The cells in champleve enameling are made in various ways; they may be etched, sawn, or chased. The easiest method is to etch them into the surface of thick metal. No. 17-gage is about right. Fig. 141 shows three hat-pins with the cells etched out ready for the enamel.

The method of etching is the same as previously described, except that it is necessary to etch a little deeper, and it is better to etch

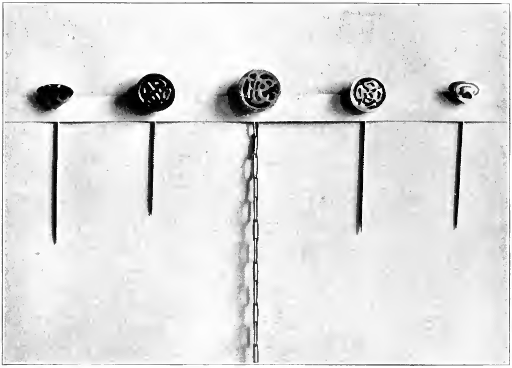

Fig. 142. "Champleve" enameling with etched cells.

Fig. 143.
Jar cover ready for enamel; chased cells.

Fig. 144
Jar cover after second firing.

a little slower than usual. The cells must be perfectly clean and bright before the enamel is put in. Fig. 142 shows a number of silver and copper tie-pins with enamel in cells that are etched out. It is necessary to solder the pins on with soft solder, as the heat from the hard soldering would discolor the enamel. The cells in some of the tie-pins are only partially filled with enamel; this leaves the surface of the enamel concave, which gives a graduation of color that is sometimes quite pleasing.

In the silver watch-fob, Fig. 145, the cells were sawn out with

Fig. 145. "Ch mpleve" enameling with sawn cells.

the saws and saw-frame previously described. The design was transferred to a piece of 20-gage sterling silver and the cells sawn out. This piece was then soldered on to another piece of sterling silver, thus making cells of the sawn-out design. The cells were filled with enamel, which, after firing, was ground level with the carborundum stone and fired again for the final glazing.

In the case of the jar cover the cells were made by the chasing method, Fig. 143. The cover was filled with chaser's pitch, then stuck on to the pitch block,[15] and the design was outlined with the "tracers" and the cells were made by beating the metal down with the "planishers." This style of chasing is known as "recess"

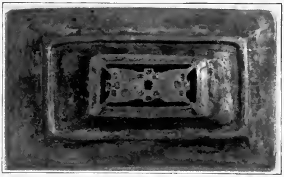

Fig. 146. Square box cover with enameled handle.

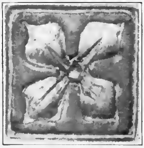

Fig. 147. Chased silver hat-pin background of blue enamel.

chasing, and makes an easy and effective method of decoration in itself. The same cover is shown after two coats of enamel have been melted on, Fig. 144. It is now ready for grinding level with the carborundum stone, and the final firing to obtain a smooth,

Fig. 148. Mortar and pestle, pieces of enamel, spatula, and carborundum stone.

shiny surface. The square box cover, Fig. 146, is another application of the chased cells. The chased silver hat-pin, Fig. 147, is a further modification of chasing and enameling. When champleve cells are made and a design chased or carved in the bottom of the cell, the name basse-taille relief, or repoussé, is given to the work.

[15]See Fig. 134, p. 163.

A transparent enamel is always used with this type, the design at the bottom being seen thru the enamel.

Etching, sawing, and chasing are the easiest methods of making the cells for the enamel. These having been described, we will now take up a description of enamel and the methods of applying and firing it. As stated before, enamel is a glass that is colored with metallic oxides. Opaque white is colored with oxide of tin, cobalt blue with oxide of cobalt, yellow with oxide of uranium, green and turquoise with oxide of iron, violet and purple with oxide of manganese, and so on thru many various shades and colors. All colors may be obtained in opaque or transparent enamel. The enamel is bought by the ounce, and comes in flat cakes about 5″ in diameter and $\frac{1}{4}$″ thick.

The enamel is broken into small pieces with a hammer and ground to powder in a wedgewood mortar with the pestle. A 3″ mortar is plenty large enough for the beginner. Fig. 148 shows the materials referred to. It is best to have a little water in the mortar to stop the small pieces of enamel from flying out. Do not pound the enamel, but place the mortar on a chair and make use of the weight of the body to grind the enamel.

After the enamel is ground about as fine as the finest salt, wash it by filling the mortar with water, allowing the enamel to settle; then pour off the water, which will be somewhat milky in color; repeat this two or three times, until the water is clear. Then fill the cells with the wet enamel, using the spatula as a spoon. The spatula is a piece of $\frac{1}{8}$″ square steel hammered to a spoon shape on one end and to a point on the other. When the cells are full, tap the edge of the metal with the spatula. This will make any air bubbles come to the surface and will make the enamel settle down perfectly smooth. Care must be taken to fill the cells carefully and not to leave any enamel on the metal surface. Next apply the edge of a piece of soft blotting paper to the edge of the enamel; this will draw off the water.

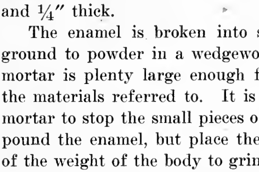

Fig. 149. Inside construction of home-made enameling muffle.

The enamel is now ready for firing. Small pieces may be fired over a Bunsen bruner or any blue gas flame; the larger pieces, requiring more heat, may be fired over the hotter blowpipe flame. But in either case it is absolutely necessary that the flame should not come in contact with the enamel, as the flame will reduce the metallic oxide with which the enamel is colored, and spoil the color of the enamel. A twisted flattened bunch of fine iron wire is a good support for the piece while it is being fired. Heat the piece slowly

Fig. 150. Inexpensive homemade enameling muffle.

until the moisture in the enamel is evaporated, then hold the piece steadily in the flame until the enamel melts and glazes. Allow it to cool slowly, as any sudden cooling is liable to crack the enamel. The enamel will have shrunk considerably in the firing, and it will be necessary to fill the cells a second and perhaps a third time, if it is desired to have them full and level. If the enamel is to be flush and smooth with the surface of the metal, it may be ground level with the carborundum stone wet with water, or with a smooth sharp file. The piece is then fired again to get the finish glaze. Sometimes the cells are first filled with a colorless transparent enamel, called "fondant" or "flux"; and the colored enamel applied as a second filling; this makes the color lighter and more transparent.

The pieces of enamel work that for any reason cannot be fired over the open flame of the Bunsen burner or blowpipe may be fired in a muffle. A muffle is a furnace in which the flames pass around a clay dome in such a way that the dome and the work get red-hot, but the flame does not touch the work. Muffles that are placed on sale are expensive, the cheapest costing about $17.00, and they are also expensive to operate, usually requiring about one hour to melt the enamel. However, a perfectly satisfactory muffle can be easily made to use in connection with the blowpipe and foot bellows. The muffle shown, Fig. 150, is made from a two-gallon oil-can, some broken brick and fire clay, and a clay dome that costs seventy-five cents, making a total cost of about $2.00. This home-made muffle costs less to operate than the ones sold in the market, as it will get hot and melt the enamel in about fifteen minutes. Figs. 149 and 150 show the manner in which the muffle is made. If at any time it is desired to remove small pieces or specks of enamel, repeated applications of hydrofluoric acid will remove them.

It is always advisable to test the enamel before using it on any valuable piece of work, as enamels are sometimes found the fusing point of which is higher than that of the metal it is to be melted on. I have had more uniform success with the enamels of the Chas. M. Robbins Co., Attleboro, Mass., altho Devoe and Reynolds, Drakenfeld & Co., and the John Dixon Co., all of New York City, sell good enamels of various grades. Some enamelers mix a very small amount of borax or a little oxide of lead with enamel that does not melt readily. This is a convenient thing to know for use in exceptional cases, but enamels treated in this way are never so good as when the proper materials are used. The best results are secured by buying good enamel and then testing before using.

Chapter XX.

SPOON-MAKING.

There is one problem in art metalwork—spoon-making—that has a distinctive charm of its own. Every worker in metal sooner or later wants to make a spoon. Handmade spoons are invariably of copper or of sterling silver, altho I see no reason why aluminum should not be used in some cases. Copper is usually used for the large nut spoons and silver for all other kinds.

There are five different methods of making spoons, the method

Fig. 151. Nut-spoon made of 18-gage copper, fire method: nut-pick of round wire.

varying according to the material used and the use for which the spoon is designed. The first and easiest method is often used in making nut spoons of copper similar to those shown in Figs. 151 and 152.

A design is first drawn on paper. Both sides should be made exactly alike by folding a piece of paper down the center and

Fig. 152. Salt and-nut spoons, first method.

drawing one-half of the spoon on one side of the center line. Fold the paper and rub the design on the back with some hard object, and the drawing will be transferred to the other side of the center line. Transfer the design on to a piece of 18-gage copper, and cut to the line with the shears, or saw it out with the jeweler's saw. Then place the spoon bowl over the hollow in the block of hard wood that was used in making bowls, and with the ball-pein hammer beat the spoon bowl into the hollow as smoothly as possible.

The handle, if it were left flat, would not be stiff enough to serve its purpose, so a ridge is raised down the center of its entire length for the purpose of stiffening it. This is done by laying the handle face downward on a piece of soft wood and using a thin neck hammer to beat up the ridge. This ridge can plainly be seen in Fig. 151; in Fig. 152 it is not defined so sharply, but it may be seen that the narrow shank of the handle is well rounded to give the required stiffness.

After the spoon is beaten into shape on the wood, it is carefully planished, polished, colored, and waxed. When using this first method, great care must be taken to make the spoon stiff. If this is not done, the spoon will bend when used, and there is no greater abomination than an object that is so poorly constructed that it breaks down when put to the use for which it was designed.

Fig. 153 shows a group of copper nut spoons made by the second method, which is somewhat similar to the first method, the chief difference being that in the second the spoon is sawn out of 15-gage metal. This does away with the necessity for the ridge in the handle, but the spoon is somewhat heavy and feels rather clumsy to handle. The illustration shows an effective means of decoration for nut spoons—that of saw-piercing a design on the handle or in the bowl. Enamel could also be used to advantage in small designs on the handle, as the cells could readily be etched out in such thick metal.

The third method of spoon-making is used largely in the making of silver teaspoons, and is especially convenient when making spoons with large bowls, similar to the silver soup spoons shown in Fig. 154. In this method the spoons are sawn out of a flat piece of 15-gage silver. The spoon is not sawn out full size, but shorter in length, narrower in the bowl, and thicker in the shank, as is shown in Fig. 155. The larger spoon of the two is the shape of the finished spoon. It is 6″ long, and the bowl is 1⅜″ wide at the widest part; but when it was sawn out of the flat silver it was

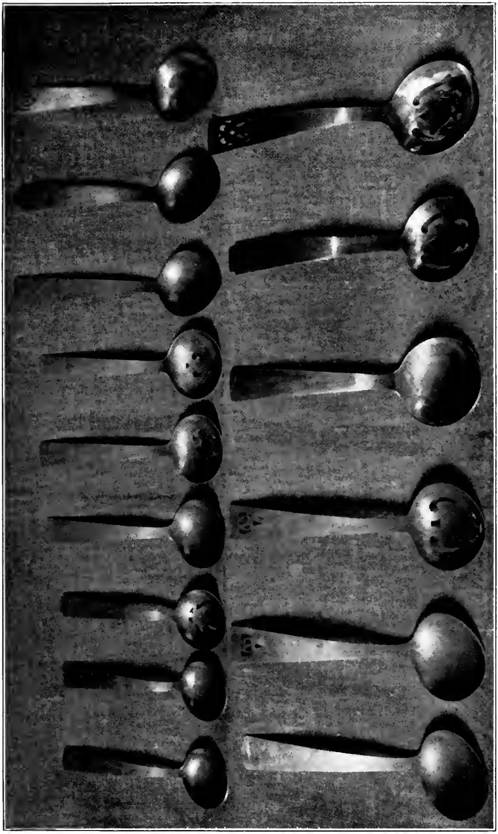

Fig. 153 Plain and saw-pierced nut-spoons. Made of 15-gage copper, by the second method.

Fig. 154. Silver soup-spoons, made by the third method.

5″ long, and the bowl was $1\frac{1}{8}$″ wide, and the shank was $\frac{5}{16}$″ wide, as shown by the smaller spoon in the sketch. The spoon was beaten and hammered into the desired shape by the use of the ball-pein and neck hammers on the flat and round stakes.

The first step is to stretch the bowl wider by hammering on a flat anvil, striking the silver with the hammer held at a slight angle in the direction in which it is desired to make it wider. The method of hammering the bowl is shown in Fig. 156, this hammer-

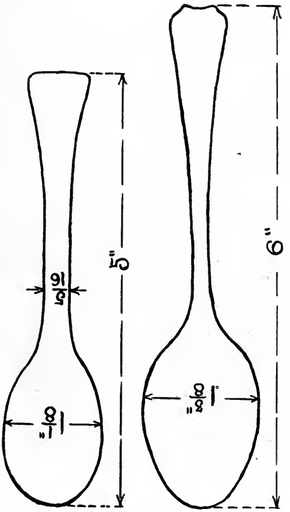

Fig. 155. Spoon-making by the third method. Outline of spoon before and after hammering.

ing making the bowl thinner and wider. Next, the spoon is held on edge, on a rounding convex stake, and the shank is hammered narrower with the neck hammer, as shown in Fig. 157. This will lengthen the spoon and at the same time will make the shank narrower and thicker. The tip of the handle is widened in the same manner as the bowl, and then the spoon will have to be annealed, and the process repeated and continued until the spoon is beaten roughly into shape. The rough edges are then filed smooth, and finally the entire spoon is carefully planished.

The spoons may be polished by hand or on a lathe; in either case, remember the "fire scale," a description of which has been given before. The best course to pursue with silver spoons is as

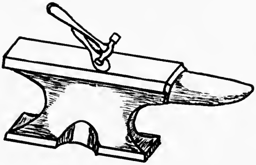

Fig. 156. Making the spoon bowl wider with the ball pein hammer.

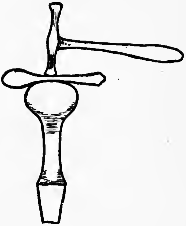

Fig. 157. Making the spoon shank narrower and thicker with the neck hammer.

follows: polish all the scratches and file marks out with emery cloth, if the spoon is to be hand polished, or on the felt or leather wheel, with powdered pumice-stone, or coarse "tripoli," or oil and emery, if the polishing is done on the lathe. Then anneal the spoon thoroly to bring the fire scale on to the spots where it has been filed or polished off. Next planish the spoon on smooth tools with smooth bright hammers, and polish lightly with a piece of canton flannel with a little red rouge for the final finish.

The fourth method of making a silver spoon is literally to forge it out of a bar of silver. The spoons shown in Fig. 158 were made by this method. This is the most difficult, but is the least expensive of the five methods, as there is less silver wasted. To make a teaspoon 6″ long we shall need a piece of silver 4″ long, ½″ wide, and ⅛″ thick. The method pursued is exactly that of the blacksmith, the silver being heated almost red-hot, and held by a pair of pincers while the bowl is forged out on an anvil. A forty-pound anvil may be bought for $4.00. Its flat polished surface and round horn make it an ideal tool for the spoon-maker, besides being of constant use in many other ways to the art metalworker.

Silver may be forged easier if it is nearly red-hot; care must

Fig. 158. Silver cheese-knife, jelly-spoon and teaspoons hand-forged by fourth method.

be taken, however, not to hammer it while it is red-hot, as it will crack. The bowl should be hammered until it is hard, and then shank and handle; thus saving time by getting the entire spoon hard before annealing a second time. When the spoon is forged roughly to shape, trim it with the shears and file, then planish and polish as described above.

The fifth and last method of making silver spoons is that of cutting the bowl from a piece of 18-gage silver, beating it into shape, and making the handle from a piece of 13-gage silver. The handle of the spoon shown in Fig. 159 was made from a piece 3½″ long, $\frac{5}{16}$″ wide, and 13-gage thick. The shank was hammered on the edge until it was square, and the tip hammered out on the flat anvil until it was thinner and wider. This process lengthened the handle to 4¾″. After the bowl and handle are soldered together it is necessary to planish the spoon again to make it stiff and hard, as the soldering anneals the silver and makes it soft.

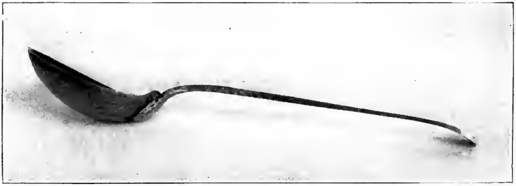

Fig. 159. Sugar spoon, made by the fifth method.

The spoon shown illustrates an ideal use of this process of spoon-making. The fact that the spoon and handle are two pieces, soldered together, has been honestly recognized; and, furthermore, it has been emphasized and used as a means of decoration. This is one of the basic principles of good design, and should be kept constantly in mind when working in any material, and especially in art metalwork, where there are so many opportunities to make use of it.