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Introducing the secondary student to sculptural design and form in metal : welding sheet steel using the oxyacetylene torch

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This thesis deals with the application of simple oxyacetylene welding techniques to the secondary art curriculum. Welded sculptural forms in sheet steel have been the focus of my own work during the past three years and these experiences formed the basis or background of the presentation of these skills to secondary students. An instructional unit was designed to fulfill three primary objectives. First, to familiarize the student with the basic tools and materials used in the construction of welded steel sculpture; second, to introduce the student to the creative concepts involved in the creation of

sculptural form; third, to give the student liberal opportunity to explore the possibilities inherent in the materials. The unit was based on three presuppositions:

1. The secondary student's initial experiences in an unfamiliar medium will be more satisfying if the skills and attitudes being introduced relate closely to ones already known and appreciated.

2. Less resistance will be expressed toward a new form of expression if theory and historical background follow direct experiences.

3. Balance between structure and creative freedom can produce satisfactory results and an appreciation for sculptural form.

The unit was organized into three assigned projects. Each project assignment was designed to direct the student's exploration of sculptural form in a predetermined direction. Some limitations were placed on each project to minimize the possibility of frustration while allowing the student a great deal of creative freedom within those limitations.

The first project dealt with the construction of a vertically oriented wire form incorporating small sheet steel elements. The objectives of the first project were to introduce the student to the tools, materials and processes involved in welding metal and to give the student an opportunity to explore design possibilities in a relatively easy medium with which to work.

The second project involved the design and construction of a relief form using a twelve inch square piece of sheet steel. Edge strips were welded in place to establish the various planes of the relief. The objectives of the second project were to introduce the student to metal forming, tacking and seam welding techniques and to allow for design experience in a more demanding medium.

The third project required the design and construction of a simple geometric closed form. The objectives were to give the student further experience in tacking and seam welding while allowing for exploration of design possibilities in three dimensional sculptural form.

The response to this unit and its results were generally positive for all of the students who participated. Keeping up the momentum proved difficult at times because only two or three students per class period were involved. Equipment limitations were also a restricting factor. The first project was most successful in terms of the student enthusiasm and variety of work produced. While the quality of work in the second project was high a number of students became frustrated with the difficulties of welding and finishing their reliefs. The results of the third project were not as satisfying as the first two. This may have been due to the difficulty of the second project and the closeness of the end of the school year.

I recommend this unit of study with the following qualifications: The teacher should be thoroughly familiar with the nature and use of the equipment; the classroom may need to be altered to meet the special physical requirements of this process and the specialized tools and equipment should be available for cutting and finishing sheet metal.

INTRODUCING THE SECONDARY STUDENT TO SCULPTURAL DESIGN AND FORM IN METAL: WELDING SHEET STEEL USING THE OXYACETYLENE TORCH

by

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CHAPTER I

INTRODUCTION

The creation of welded metal sculpture involves techniques and processes that fascinate most secondary students. Perhaps it is the opportunity to control and use fire in this special way or the sense of power one feels at dissolving the strength of normally unyielding materials. The fire arts involve some of the oldest and most important manufacturing skills known to man. In many primitive cultures the metalsmith also served as the spiritual leader of his community and it was believed that his craft contained much that was mystical and magical. In spite of the technological sophistication which attempts to overwhelm our culture there seems to be an undercurrent which ever draws us back to more basic human experiences. Perhaps it is a part of this primitive excitement we experience when we light an oxyacetylene torch, apply the flame to a piece of cold, hard steel and watch the metal glow, then melt and flow into a golden, shimmering puddle.

Although the basic techniques of welding, soldering and brazing have been known to man for well over 4000 years, many new processes have been developed in the last century that have greatly increased our abilities and versatility in working with metal. Of these developments the most significant in relation to this thesis was that of the commercial production of acetylene gas from calcium carbide.

"Although acetylene was discovered as early as 1836, it was not widely used, except in laboratories, until 1892, when a method of producing calcium carbide in large quantities was discovered."[1] "In 1895 a French chemist named Le Chatelier discovered that acetylene mixed with oxygen produced the hottest flame known since Prometheus stole fire from the gods (5300 -6300 F)."[2] It was not until 1903 in Europe and 1907 in the United States that equipment became generally available for industrial use that was capable of producing and controlling this flame. This development gave man a new and highly versatile tool for rapid fusion of many metals. This technique has become commonly known as oxyacetylene welding and is used extensively by both industry and the arts in the creation of metal implements and artifacts.

The application of modern industrial processes to the arts was summarized by Irving Kaufman:

> Though technology has engendered a fearsome mechanical imposition on our lives, it is not an inappropriate condition for our century. Despite the sharpness of the industrial scene, there is a sense of power and what could be an intrinsically satisfying plan of achievement. Process and engineered efficiency possess a beauty of their own.... Technology is not only a source for products and wealth, it is also a fundamental source of philosophical understanding as well as a generator of creative visual form today."[3]

[1]Boniface E. Rossi, Welding Engineering (New York: McGraw-Hill, 1954), p. 44.

[2]John Baldwin, Contemporary Sculpture Techniques: Welded Metal and Fiberglass (New York: Beinhold, 1967), p. 26.

[3]Irving Kaufman, "The Visual World Today", Report of the Commission on Art Education, ed. Jerome Hansman (Washington D.C.: National Art Education Association, 1965), p. 18.

Baldwin charts the origins of welded sculpture from 1927 when Gonzalez, whose father was a goldsmith in Barcelona, was called upon for technical assistance by Picasso around 1930 when he became interested in forming constructions in wire. David Smith followed the lead of Picasso and Gonzalez and in 1933 produced what is believed to be the first piece of welded sculpture in America.[4] Smith made the following statement regarding this new creative medium: "The metal possesses little art history. What associations it possesses are those of this century; power, structure, movement, progress, suspension, destruction, brutality."[5]

To understand more fully the development of welded metal sculpture one needs to explore the origins of cubism and the reaction to "... the disintegration of structure and volume that takes place in Impressionist painting and sculpture."[6] Picasso's earlier wood constructions represented a return to solid form from the dreamy, ethereal qualities which characterized Impressionistic painting. In these early works Picasso and his contemporaries anticipated the form that this reaction to Impressionism was to take. A group of Moscow artists was probably influenced by contemporary French painting. These artists, including Tatlin, Malevich, Rodchenko, Pevsner, Gabo and others, "... quickly went through a development that included Impressionism,

[4]Baldwin, p. 25.

[5]Baldwin, pp. 25, 26.

[6]Herbert Read, _A Concise History of Modern Sculpture_ (New York: Praeger, 1964), p. 88.

Post-Impressionism and analytical Cubism."[7] Their belief was that the function of art was to "... research into basic elements of space, volume and colour, in order to discover, as they said, the aesthetic, physical and functional capacities of these materials."[8] Though eventually repressed by new government in the Soviet Union the influence of these artists was felt for decades to come. While a complete discussion of the development of these trends is beyond the scope of this paper, examples of constructive techniques can be found in Picasso's wire space cages, Calder's mobiles and stabiles, and the plexiglass and chromium-rod sculptures of Laszlo Moholy-Nagy.

My own experience with the oxyacetylene welding process began with an adult education class at Clackamas High School. It was further developed during my undergraduate studies in sculpture at Portland State University under James Lee Hansen. One year after graduation from P.S.U. I began teaching Art Metal at Franklin High School in Portland, Oregon and have kept active in my own personal creative pursuits. These have generally taken the form of cast plaster relief in sand, bronze castings and welded sheet metal forms. By preference, my own studio space is oriented more towards welding than either bronze or plaster casting. I have found in welding a personally satisfying synthesis of the careful form resolution that is basic to metal smithing and the more direct approach that permits the sculptor to discover the final form as a piece of work develops.

For the past several years I have had oxyacetylene equipment in

[7]Read, p. 89.

[8]Read, p. 101.

my classroom and have made it available to select students on an individual basis. It has been my goal to expand the use of this equipment to include a greater number of my students and to introduce them to the experience of creating sculptural forms in metal. This thesis documents my attempt to design and implement an educational plan which will accomplish this goal.

CHAPTER II

A PROPOSAL FOR THE SOLUTION TO THE PROBLEM

> Technique is a part of the creative process. Through the mastery of techniques the sculptor is able to form intractable materials and imbue them with spirit and vitality. A sculptor cannot conceive of a work without taking into account the materials and techniques he will use.[9]

One way to introduce the secondary student to the techniques of creating sculptural form and design in metal is to develop an instructional unit that will give the student an opportunity to explore the creative possibilities of the materials while providing for a reasonable assurance of success. Instruction in the use of unfamiliar and potentially hazardous equipment requires a carefully designed structure or framework which will allow the student enough freedom of exploration while offering adequate protection from both physical injury and frustration. The student needs to experience a reasonable amount of success during the learning process and to create a product that reflects the value of that process.

When any new form of artistic expression is explored in the secondary curriculum it should be introduced in a way that insures that the student's initial experiences be ones of enjoyment and anticipation of continued opportunity for exploration. The unit must be designed to afford an adequate balance between structure and freedom.

[9] Baldwin, p. 9.

The problem faced is one of structuring a series of projects or assignments that facilitate the introduction of the basic concepts of sculpture via the student's own work.

The development and presentation of this instructional unit is based on the following three presuppositions:

1. The secondary student's initial experiences in an unfamiliar or new form of creative expression will result in a much more satisfying experience for the student if the skills and attitudes being introduced relate closely to those already known and appreciated.

2. The secondary student will offer less resistance to a new form of expression if theory and historic background follow rather than precede the direct experiences in the medium.

3. Given a reasonable balance between a carefully structured assignment and adequate creative freedom the secondary student will be able to produce satisfactory results and develop an appreciation for sculptural form.

With these in mind the following three projects were designed to enable students to explore adequately the medium and to produce several pieces of sculpture that would reflect their efforts.

PROJECT ONE

Because working in sheet steel requires a fair degree of skill the student needs to have an opportunity to begin his investigation into design possibilities at a level which will allow for both immediate experience and fairly rapid results. The construction of open forms using mild steel welding rods meets both of these requirements.

The material is easy to cut and weld together with a torch and lends itself to the construction of an endless variety of design possibilities. Small pieces or strips of sheet steel could be incorporated into the sculptures. This would necessitate the introduction of basic metal cutting and forming techniques which would be necessary for more advanced projects. Students might need to be encouraged to concentrate on non-objective forms to avoid the possibility of getting locked into model building. Limitations could be placed on the project which would not severely restrict the student's efforts and serve as a discouraging factor.

PROJECT TWO

The second project could involve the practice of more advanced skills using larger pieces of sheet steel. The construction of simple relief designs would allow the students to develop in their abilities to shape and weld metal forms and prepare them for the more difficult process of constructing closed forms. Specific skills to be emphasized would include working from a pattern, tacking, seam welding and grinding. Special consideration could be given to positive and negative spaces suggested by projecting and receding planes.

PROJECT THREE

A third project could involve the creation of a small scale closed form derived from a simple geometric shape. The student would be required to have a preconceived idea as to what form the sculpture would take prior to its construction. He would need to be able to work from patterns and produce the various pieces he needed with a fair degree of accuracy. The results could be evaluated in terms of balance, structure and unity.

These three project assignments would serve to accomplish the following five objectives:

1. The student will become familiar with the set-up and safe operation of oxyacetylene equipment.

2. The student will be able to demonstrate his knowledge of basic metal working tools and their correct use. These tools will include the electric shear; left, right and straight cutting aviator snips; forming hammers and anvil; and the electric angle grinder.

3. The student will be able to demonstrate his ability to perform simple welding operations including tacking and welding seams.

4. The student will be able to construct various kinds of sculptural forms including open, relief and closed using the oxyacetylene torch.

5. The student will be able to critique his work using the following criteria: balance, dominant and sub-ordinate forms and craftsmanship.

This unit in oxyacetylene welding has been designed to last approximately ten weeks and will be presented to thirteen students in my first and second year Art Metal classes. Because of space and equipment limitations only three students from each class can be accommodated. The students were selected on the basis of personal interest, maturity, and previous good attendance. They were told that grades would be determined according to the amount of effort they put into their work rather than an evaluation of the comparative quality of what they produce. Only two students have had previous experience with the oxyacetylene equipment and none has had any direct experience with the creation of sculptural forms.

CHAPTER III

RESEARCH RELEVANT TO THE SOLUTION OF THE PROBLEM

Prior to the presentation of this unit in welding it was necessary to review the essential factors in the safe operation of the equipment. Before attempting instruction in this medium the teacher should be thoroughly familiar with the equipment and its operation.

> The process of oxy-acetylene welding is possible because of the principle that, when acetylene is mixed with oxygen in correct proportions and ignited, the resulting flame is one of the hottest known. This flame, which reaches a temperature of 6300 F (3482 C), melts all commercial metals so completely that metals to be joined actually flow together to form a complete bond without application of any mechanical pressure or hammering.[10]

Specialized equipment has been developed by industry to safely handle these gases. The nature of this equipment and its correct use will be discussed in this chapter.

THE BASIC EQUIPMENT

Cylinders

"Oxygen cylinders are made from seamless, drawn steel and tested with a water pressure of 3360 psi."[11] Cylinders for industrial use can be leased or purchased in three common sizes. The largest has

[10]Joseph W. Giachino and William Weeks, Welding Skills and Practices, 5th ed., (Chicago: American Technical Society, 1976), p. 238.

[11]Giachino and Weeks, p. 239.

a capacity of 244 cubic feet of gas, a medium size holds 122 cubic feet and the smallest holds 80 cubic feet. All three are charged at a pressure of 2200 psi at a temperature of 70 F (21 C). Pressure will fluctuate as the temperature of the cylinder rises and falls. Because of this fluctuation "... all oxygen cylinders are equipped with a safety nut that permits the oxygen to drain slowly in the event the temperature increases beyond the safety load of the cylinder."[12] This safety feature serves to prevent the possibility of an explosion in the event of a fire. The protector cap which screws onto the top of the cylinder should always be in place to protect the valve when the cylinder is not being used. Cylinders under full pressure have been known to take off like rockets when the valve is broken off at the neck.

Acetylene gas is produced when calcium carbide is combined with water. It is stored in metal cylinders that are filled with a mixture of "... asbestos, Balsa wood, charcoal, infusorial earth, cement, etc."[13] Since acetylene gas becomes dangerously unstable at pressures of more than 15 psi it is dissolved in acetone which saturates the porous material with which the cylinder is filled. A fusible plug relieves excess pressures due to abnormal heat or external pressure. Cylinders come in three common sizes: 60, 100 and 300 cubic feet.

<u>Regulators</u>

A two stage regulator is composed of two pressure gauges and a

[12]Giachino and Weeks, p. 240.

[13]The Welding Encyclopedia, 10th ed., Stuart Plumley, ed. (Chicago: Welding Engineer Publishing, 1941), p. 378.

pressure sensitive valve which maintains a constant flow of gas to the torch regardless of the change in the pressure inside the cylinders. The gauges on the oxygen regulator are usually calibrated to 3000 psi on the cylinder pressure gauge and to 60 psi on the working pressure gauge. On the acetylene regulator they usually read 400 psi and 30 psi respectively. The pressure in the hose side of the regulator is controlled by turning an adjusting screw on the body of the regulator. As this screw is turned clockwise the delivery pressure is increased. Turning it counterclockwise decreases the pressure delivered to the torch although the torch valves must be open to relieve the pressure in the hoses for the gauge reading to drop.

> The most important thing to remember when using a regulator is to make absolutely certain that the adjusting screw is released (turned out) before the cylinder valve is opened. If the adjusting screw is not released and the cylinder valve opened, the tremendous pressure of the gas in the cylinder, forced onto the working gage, may result in damage to the regulator.[14]

The operator could also be seriously injured if he is standing directly in front of the gauges when the cylinder valve is opened. Authorities recommend that the operator always stand to one side when opening this valve.

Oxygen and Acetylene Hoses

Oxygen and acetylene hoses are color coded green or black for oxygen and red for acetylene. They are made of a special, non-porous material. These hoses must never be interchanged. "If oxygen were to pass through an old acetylene hose, a dangerous combustible mixture

[14]Giachino and Weeks, p. 248.

might result."[15] The standard fittings used on oxygen and acetylene hoses are threaded in opposite directions for this very reason. The inside of a new hose is dusted with talcum powder and should be blown out before being used. Since grease and oil will eventually penetrate welding hoses and hot metal will burn it the operator should take adequate precautions against either of these potential hazards.

Torch Handles

In the torch handle, which is sometimes called a blowpipe, the oxygen and acetylene are mixed in the correct proportions to produce the flame desired. The torch is equipped with two valves which control the flow of gas through the torch tip.

> The two main types of blowpipes are the injector and the medium (equal) pressure. The injector torch is designed to use acetylene at very low pressures, from 1 psi to zero. The equal pressure type requires acetylene pressures of 1 to 15 psi. Both will operate when acetylene is supplied from cylinders or medium pressure generators.[16]

The most common type of torch is the equal pressure type in which the oxygen and acetylene are fed into the mixing chamber independently. The oxygen fitting is threaded with right-hand threads and the acetylene fitting is threaded with left-hand threads to prevent the possibility of getting them mixed up. This characteristic is generally true of all hose fittings and must be remembered when setting up equipment for welding. A lock nut at the base of the adjustment knob on the torch may be tightened if the knob turns too easily and will not hold the desired setting.

[15] Giachino and Weeks, p. 248.

[16] Giachino and Weeks, p. 244.

Torch Tips

Torch tips come in a variety of sizes which have been designed for welding different thicknesses of metal. Specific sizes vary among manufacturers however a typical range of sizes will start with 00 for small and 15 for large. Extremely small torch handles and tips have been developed for very fine work. Tips should be cleaned with either a standard tip cleaning set designed for the purpose or a drill bit the same size as the hole. Leaving the oxygen on during the cleaning process blows carbon out of the tip as it is cleaned out. The end of the tip can also be cleaned off with a fine grade of sandpaper.

Goggles

"An oxyacetylene flame produces light rays of great intensity and also heat rays which, if meeting the naked eye, may eventually prove destructive to the eye tissues."[17] A number of materials have been developed which adequately protect the eyes when welding. The degree of shade required will be determined by the sensitivity of each individual's eyes but usually goggles with a shade number of 4, 5, and 6 are recommended. Goggles also serve to protect the eyes from sparks that pop from the puddle when welding.

PRECAUTIONS

The following precautions must be followed when working with oxyacetylene equipment:

1. Never use the valve-protector caps for lifting cylinders.

[17]Giachino and Weeks, p. 249.

2. Do not allow cylinders to lie in a horizontal position.

3. Never permit grease or oil to come in contact with cylinder valves. Although oxygen is in itself nonflammable, if it is allowed to come in contact with any flammable material it will quickly aid combustion.

4. Avoid exposing cylinders to furnace heat, radiators, open fire, or sparks from the torch.

5. Never transport a cylinder by dragging, sliding, or rolling it on its side. Avoid striking it against any object that might create a spark. There may be just enough gas escaping to cause an explosion.

6. If cylinders have to be moved, be sure that the cylinder valves are shut off.

7. Never tamper with or attempt to repair the cylinder valves. If valves do not function properly or if they leak, notify the supplier immediately.

8. Keep valves closed on empty cylinders.

9. If cylinder valves cannot be opened by hand, do not use a hammer or a wrench - notify the supplier.

10. When not in use, keep cylinders covered with cylinder caps.[18]

PROCEDURE

The following procedure should be used when setting up the equipment:

1. Secure the cylinders in an upright position. This can be accomplished either by storing them on a cart designed for that purpose

[18]Giachino and Weeks, pp. 242, 243.

or by chaining them to a wall or some other fixed object. Check to make sure the connection seat or screw threads are not damaged.

2. Crack the valves to blow out any particles of dirt which may have collected in the outlet nozzle of the cylinder valve and be sure the seat is clean.

3. Using a proper fitting wrench attach the pressure regulators to the valves being careful not to cross-thread the fittings.

4. Connect the hoses to the regulators: green to oxygen, red to acetylene. Before opening the main cylinder valves back out the regulator valves until they feel loose. When the regulator valves are closed the cylinder valves should be opened slowly at first so that pressure does not build too rapidly in the gauge which reads the cylinder pressure. The regulator valves may now be opened enough to blow out any dirt which may have collected inside the hoses.

5. Hose fittings should be attached to torch fittings in the following way: the green hose to the torch handle fitting marked OX and the red hose to the fitting marked AC. Oxygen fittings always have right-handed threads and acetylene fittings always have left-hand threads so extreme care should be taken never to force the fittings if they do not start easily by hand. Reverse-flow check valves, which are now required by many school districts, should be installed between the torch handle and the hose fittings. An arrow on the side of the check-valve indicates the direction of gas flow. These valves prevent the flame from burning back towards the regulator inside the hose.

6. New equipment should always be tested for leakage with a mixture of soap and water at the following places: oxygen and acety-

lene cylinder valves, regulator inlet connections, all hose connections, and both needle valves on the torch handle. If any leaks appear

> In the acetylene cylinder valve that cannot be stopped by closing the valve or tightening the packing gland, or if the leak is at the fuse plug, remove the cylinder out of doors away from possible sources of ignition and notify the supplier immediately.[19]

Lighting and adjusting the torch are important aspects of the craft and the following procedure should be followed consistently:

1. Turn the regulator screws counterclockwise until they turn freely. Open the valves on the oxygen and acetylene cylinders. The oxygen valve should be opened just enough so that the pressure in the regulator increases slowly. When the gauge needle stops moving the valve can be opened completely to prevent possible leakage around the cylinder valve. The acetylene valve should be opened not more than one to one and one half turns. This practice permits the operator to quickly turn off the acetylene in the event of an emergency.

2. Adjust the regulators to the desired pressure by turning the handles clockwise until the gauges indicate the correct working pressure.

3. Open both torch valves no more than 1/8 turn. Even 1/8 turn may be too much on some equipment.

4. With the torch pointed down and away from the body hold a striker over the end of the torch and strike. If the torch does not light, readjust the torch valves and check to make sure the striker has adequate flint.

[19]Giachino and Weeks, p. 254.

5. After the torch lights the flame can be adjusted to achieve a neutral flame by first turning up the acetylene until just before the flame exhibits the tendency to jump away from the tip. The oxygen is then turned up until a small blue cone of flame appears at the tip of the torch. Not enough oxygen will cause a lighter blue brush to appear at the tip of the cone. This kind of flame is known as a carbonizing or carburizing flame and is undesirable for welding steel as it adds carbon to the weld which makes it brittle. Too much oxygen will produce a very sharp pointed cone and a distinctive hissing sound. This flame, known as an oxidizing flame, results in overheating the metal, causing it to throw off a shower of sparks and creates an excess amount of slag around the weld. A balanced or neutral flame, resulting from a one-to-one mixture of oxygen and acetylene, causes the molten metal to flow smoothly and will throw very few sparks.

TIP SELECTION

Selection of the proper tip depends on the thickness of the material that is to be welded. The following table gives recommended tip sizes and gas pressures for various thicknesses of metal.

> It is very important to use the correct tip, with the proper working pressure. If too small a tip is employed, the heat will not be sufficient to fuse the metal to the proper depth. When the tip is too large, the heat is too great, thereby burning holes in the metal. A good weld must have the right penetration and smooth, even, overlapping ripples. Unless the conditions are just right, it is impossible for the torch to function the way it should and, consequently, the weld will be poor.[20]

[20] Giachino and Weeks, p. 254.

TABLE I

TIP SELECTION CHART [21]

TIP NUMBER	THICKNESS (inches)	OXYGEN PRESSURE (pounds)	ACETYLENE PRESSURE (pounds)
00	1/64	1	1
0	1/32	1	1
1	1/16	1	1
2	3/32	2	2
3	1/8	3	3
4	3/16	4	4
5	1/4	5	5
6	5/16	6	6
7	3/8	7	7
8	1/2	7	7
9	5/8	7½	7½
10	3/4 & up	9	9

WELDING TECHNIQUES

Once the equipment is set up the processes of tacking and welding simple right-angle seams is relatively easy and can be mastered with practice. The first skill to learn is the tack. With the torch adjusted properly the flame is moved to the spot where the two pieces of metal are to be joined. The area of the join is heated quickly. When the metals melt and flow together the flame is removed. Tacking is usually done in preparation for seam welding and is used to carefully position two or more pieces of metal so that seams can be welded easily. One advantage to tacking is that positioning can be somewhat approximate and while the tack is still red hot the edges of the sheets can be hammered together. Tacks should be spaced about an inch apart the entire length of the seam. Spacing them further can result in the seam pulling apart between the tacks as it is welded.

[21] Giachino and Weeks, p. 255.

This problem is caused by the expansion of the metal as it is welded.

Seams can be welded either by adding filler rod as the molten puddle travels along the seam or by allowing the edge of one of the pieces to furnish the material for the weld. It is important to provide enough but not too much material for the weld. Excess material not only takes longer to melt but may have to be ground off later in the finishing process.

The skill of melting the metal into a puddle and moving the puddle along a seam does require concentrated practice. Keeping the torch moving in a tight, orbital pattern around the puddle helps maintain the correct temperature and keeps the puddle moving. Holding the torch on one spot too long can overheat the metal and cause popping which sends out showers of sparks.

CHAPTER IV

METHODS AND TECHNIQUES

ASSIGNMENT ONE

The first assigned project was the construction of an open sculptural form using 1/8 inch welding rods as the primary structural component and adding some small pieces of sheet steel as design elements. The length of time devoted to this project was two weeks.

During the initial presentation, which lasted about 50 minutes, I covered the basics of oxyacetylene welding, the steps in setting up the equipment, how to light the torch and adjust the flame and stressed the need for safety. At the end of the first presentation each student was given the opportunity to practice the start-up procedure and adjust the torch.

On the second day the objectives of the assignment were discussed and each student was given a small wooden block for a base and instructed to drill at least six holes into one side of it with a 9/64 inch bit. The holes could be drilled in a pattern or randomly spaced. Correct use of the electric metal shear was also discussed and the students were directed to cut at least five strips of 18 ga. sheet steel. Welding rod was provided as needed. The small block of wood was provided as a subtle means of limiting the size of the sculptures without placing arbitrary restrictions on dimensions and to assist students in determining the orientation of their design. Without some kind of size limitations the rapid growth potential of this medium in combination with a natural adolescent tendency towards competitiveness and the commonly held notion that bigger is better can produce some pretty ungainly results.

All of the sculptures remained relatively small, between 12 and 24 inches high. Because of the small base most of them began as essentially vertical structures. Several of the students were able, however, to incorporate horizontal and diagonal elements which contributed greatly to the success of the design. Planes and contours were suggested by incorporating strips of sheet metal into the design.

When the assignment was first discussed I had asked the students to concentrate on constructing a free-form nonobjective design rather than basing their sculpture on some preconceived familiar form. Several apparently found this frustrating and insisted on trying to build models of cranes, playground equipment, etcetera. Those who did avoid model building expressed satisfaction with their work but seemed to feel awkward discussing their work as design rather than how much it resembled familiar forms. The students also had difficulty knowing when to quit building. The forms just kept growing and for most the only reason they stopped when they did was that the time allotted for the assignment had expired. Only two actually stepped back from their work and said they were finished. The rest simply quit working on them.

One student chose to do his first piece entirely in sheet metal strips. Since he had prior welding experience and had exhibited a high degree of motivation in the past, I encouraged him to see what he could do. The results of his experimentation were generally successful and I was reminded of the necessity of remaining flexible as a teacher.

All of the students began their designs as a symmetrical framework of vertical rods which was expected. I was surprised by the extent to which some of them were able to break away from a dependence on symmetry, a dependence which is constantly exhibited in secondary design. All of the sculptures demonstrate a confident handling of the problems involved in maintaining a balanced design, however, some of the students were much more conservative in their approach than others. Several of the students went beyond the assignment in their experimentation with the materials and began incorporating the 1/16 inch rod, which was originally intended for use as filler material, as design elements.

During the time that the students were working on their first project I decided to experiment with a design that I had wanted to do for several years. I was also interested in seeing if the students would pick up any ideas either directly or indirectly from my working along with them.

ASSIGNMENT TWO

The second assigned project was the construction of a twelve by twelve inch welded relief in sheet steel. The surface of the form was to be closed with no open spaces. Seams were to be fitted, tacked and welded and excess material was to be filed or ground off. Tacking and seam welding techniques were demonstrated and discussed.

Students were encouraged to practice briefly on small scrap pieces before starting.

Each student was given a twelve inch square of 16 gauge sheet steel and graph paper and instructed to draw a design which broke up the square into no more than six areas. The limit of six areas was intended to keep the designs relatively simple. The students' designs were discussed in terms of balance, dominance and subordinance of various shapes and potential difficulty of construction. Many of their initial designs were symmetrical as I had anticipated they would be. After discussing potential difficulties with symmetrical designs all but two decided to do an asymmetrical design instead. I did intentionally discourage several students from attempting designs which I thought would be either too difficult or too symmetrically rigid. The students used the electric shear to cut out their designs in the metal. The curved lines in their designs provided an additional element of difficulty in this skill. The process of hammering a convex curve into the surface of the metal was demonstrated and discussed. Several students became over enthusiastic with the opportunity to hammer and had to spend extra time hammering dents out of the pieces of their project.

After the pieces were cut out and hammered the students were instructed to begin deciding which areas of the relief would become foreground and which background. One student saw the possibility of using columns of plasticene clay to hold the pieces in position while these relationships were resolved. Most of the others adopted this innovation as well. Students were shown how to make paper patterns for the strips of metal which would separate the sections and were strongly encouraged to tack all of the pieces together before they started welding any seams. The temptation, however, to begin welding as soon as possible was too strong for all of the students. As a result several of the projects became quite distorted from the original design. Several attempted to use the torch as a metal cutting tool. This left masses of melted steel along the edge they were cutting and made it almost impossible to weld a smooth seam. A cutting torch was not available for demonstration or use at the first of the project and many of the students were not aware that it was a separate tool. As work progressed it became apparent that the projects were not going to be completed in the time allotted. An extra week was given at the expense of the final project in hopes that the last project would not take as much time.

One of the problems which contributed to the need for extended time was the fact that only one angle grinder was available. It was on loan from the metal shop and was not always available. Grinding the welds took longer than anticipated because of the tendency to build up more material along the seam than necessary at first. Definite progress could be seen as they became more experienced and their initial tendency to overload the seam diminished considerably. As the students finished welding the designs they were instructed to begin giving consideration how their sculpture would be mounted. The construction of a simple wood frame was demonstrated and some lumber was provided. Assistance was given in solving some of the technical problems of construction and the need for attention to details was stressed.

ASSIGNMENT THREE

Most of the students began the third assignment before finishing the second. During times when the equipment was unavailable they could continue the finishing and framing of their welded relief. The final project involved the design and construction of a closed geometric form. All seams were to be welded and ground relatively smooth. This project offered the students additional experience with all the basic tools introduced in the first two assignments. The following reproductions were shown and discussed to illustrate a variety of welded steel forms based on simple geometric shapes:

Vantongerloo. Sculpture in Space: $y=ax^3-bx^3$, 1935.

Chadwick. Winged Figures, 1962.

Smith, D. Cubi IX, 1961.

Volten. Architectonic Construction, 1958.

Aeschbacher. Figure XI, 1960.

Schnier. Cubical Variations within Rectangular Column, 1961.

The students were provided with stiff cardboard and instructed to work out their designs before beginning their sculptures. I attempted to spend more time on individual instruction in welding skills with this assignment. I wanted to see the students give more careful consideration to fitting and tacking the parts before they began welding the seams.

Since all chose to work with variations of the pyramid or cube, the planning and pattern making stage of this assignment progressed quite rapidly. For most, one class period provided sufficient time to select a basic shape and cut out patterns. Some even had their metal cut and were ready to begin welding on the second day. The tacking and welding process also seemed to take less time, however, most experienced continued difficulty trying to weld too much material into the seam. Popping continued to be a problem for most though not as often as at first. All seemed to approach the final project with adequate confidence in their own abilities but with noticeably less enthusiasm than with their first assignment. The size and difficulty of the second project may have dampened some of their initial excitement with the welding process.

The most difficult and perhaps most frustrating aspect of the series of projects was encountered in the finishing process. The only grinder available was a light weight Bosch angle grinder which I borrowed periodically from the metal shop teacher. While grinding was considerably faster than filing, the grinder was only available to one student at a time. The grinding disks were expensive and broke very easily. Most students simply ran out of time before they finished and mounted either their reliefs or their closed forms.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

In spite of the potential problems, the introduction of oxyacetylene welding into the curriculum of my Art Metal program was both productive and personally challenging. The most difficult and at times frustrating aspect of the project was finding the time to adequately meet the needs of those students in the classroom who were not involved in the welding assignments. Student response to the series of assignments was generally enthusiastic. Several asked about the possibility of continued work next year. A number of students who were not involved also expressed interest in learning about the equipment and its use. Two students inquired about the cost of buying equipment for their own personal use at home. Responses and inquiries of this nature lead me to believe that welding has good potential for introducing students to a wide range of sculptural and design experiences. Specific conclusions fall into three main categories: design of the instructional unit, safety in the classroom, and student motivation.

DESIGN OF THE INSTRUCTIONAL UNIT

Project one was intended to be quite free and open for student experimentation, yet with certain subtile limitations, such as limiting the size of the wooden base. Of the three assignments this was by far the most successful. The students approached the project with enthusiasm and anticipation. The immediacy of the results was undoubtedly one of the primary reasons. The fact that it was their first opportunity to use oxyacetylene equipment also contributed to this excitement.

Placing limitations on student designs produced mixed results. Requiring nonobjective or freeform constructions was received relatively well by most of the students. It was certainly successful in helping most of them to break away from what could have resulted in unproductive attempts at model building. Several students experienced difficulty breaking out of this pattern as can be observed in their work. Only one student began an open form which was rigidly symmetrical. He soon lost interest in the project, however, and did not finish. When I present this unit in the future I shall try to allow more time for students to work through this problem. Secondary students need to experience the freedoms of nonobjectivity and asymmetricallity in their designing if they are to progress in their creative development.

Another phenomenon which I observed was that many of the students placed little value on their finished projects. They seemed much more interested in the future potential of what they could do with the process than in their first attempts, even though some of those attempts were quite good. This also served as a reminder that one of the primary tasks of the art teacher is to help bring students to the point where they are able and willing to consider seriously the value of their own creative abilities. Additional time could have been spent discussing the results of the assignments with students. It would have been better if all the students involved could have been present for group critiques. Since there were only two or three in each class this proved impossible.

Project two was definitely too difficult a challenge for most of the students. A smaller design that involved only two or three separate areas could provide the same kind of experiences without dampening student enthusiasm. Because of technical difficulties two students were unable to finish welding their second projects. Tacking all of the pieces in place and checking for proper fit is critical and must be done before the seams can be welded. In spite of the difficulties, I was quite pleased with the overall results. Several students enclosed their reliefs with simple wood frames which helped enhance the metal forms.

The results of project three were generally disappointing. The following three reasons were primary contributing factors: (1) The previous assignment was too difficult and most of the students had peaked in terms of their creative energy and output. (2) The students were not excited by either the illustrations shown or the prospect of constructing simple geometric shapes. Those who made pyramids saw them more as models than as pieces of sculpture. (3) For the seniors involved in the project there were only a few days of school left and they were understandably preoccupied with more personally significant events. The rest of the students only had a week or so of school left after the seniors graduated. Their thoughts and energies were also gravitating away from school projects.

When I present this unit again I shall simplify the second project and adjust the schedule so that it does not crowd the end of the year.

SAFETY IN THE CLASSROOM

Guarding against potential hazards must be a fulltime preoccupation for any teacher who assumes responsibility for teaching oxy-acetylene processes in the secondary classroom. Extra care should be taken in the following areas:

1. Keep welding stations clear of flammable materials. Welding tables should be constructed of metal and surfaced with brick. Ideally the floor should be bare cement. A linoleum floor could be covered with sheet metal.

2. Stations should be far enough apart so that a welder will not accidentally burn the person working next to him with either the torch flame, a hot piece of metal or showers of sparks.

3. The instructor should tolerate absolutely no play around the equipment. A series of incidents in connection with these projects resulted in the necessity of having one of my non-participating students permanently removed from the classroom. This unfortunate measure was used as a last resort when warnings were not taken seriously.

4. Gloves should be provided to protect students' hands when working with sharp metal edges. Sheared metal can cut quickly and deeply. Gloves also offer protection from potential burns.

STUDENT MOTIVATION

Student motivation is perhaps the most difficult element to control in any curriculum. How material is presented, timing, expectations and general student-teacher rapport are all important factors in motivating students in a given area. I feel that doing my own work where students could observe and having pieces of my work in the classroom helped to motivate students in this project. Seeing what I had done encouraged the students to have confidence in my abilities to help work through potential problems. It was not, however, an adequate substitute for a broader exposure to examples of sculpture available in the Portland area. Hopefully, a field trip or tour of local work could be added to any future presentations.

Working by two's and three's was also a limiting factor in terms of motivation. On the secondary level it usually takes a larger group to keep up the momentum through the less exciting parts of a particular project. The teacher will at times have to encourage students by supplying enthusiasm when student interest is low.

Some kind of culminating activity is also helpful. It might be a show of student work, a review or critique or even just a photography session. It is very important that each piece of student work receive serious consideration and adequate recognition by the teacher. Students learn to see the value of their own efforts as they see it valued by others.

RECOMMENDATIONS

I would recommend the incorporation of oxyacetylene welding processes into the secondary art curriculum with the following qualifications:

1. The teacher should be thoroughly familiar with the nature and use of the equipment.

2. The classroom space should be adequate for the requirements of the process.

3. The necessary tools and equipment should be available for cutting and finishing sheet metal.

It should be understood that the specific results of any instructional unit are unique to a particular situation and that the results realized by any other teacher may be significantly different. In fact my own investigation into this area of instruction is only barely past its point of beginning and will undoubtedly produce different results as it continues.

SCULPTURES BY THE STUDENTS

FIGURE 1

FIGURE 2

FIGURE 3

FIGURE 4

FIGURE 5

FIGURE 6

FIGURE 7

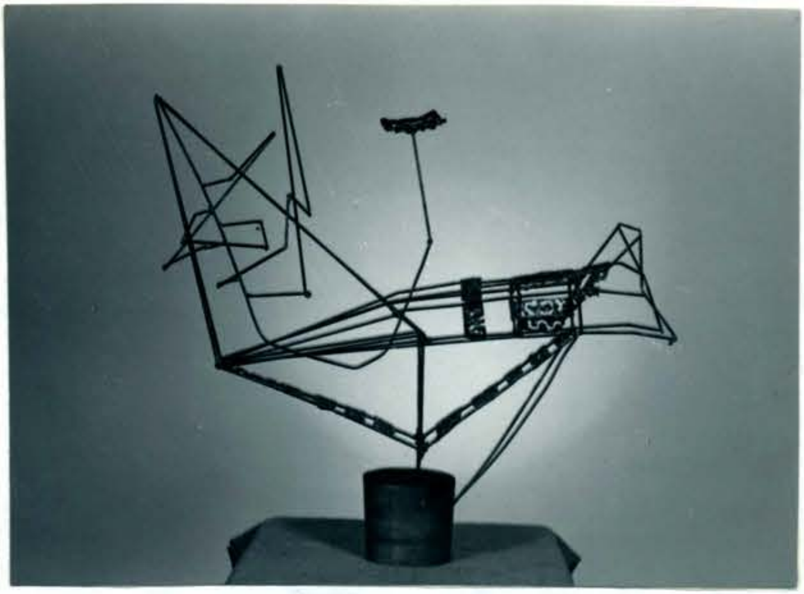

FIGURE 8

FIGURE 9

FIGURE 10

FIGURE 11

FIGURE 12

FIGURE 13

FIGURE 14

FIGURE 15

FIGURE 16

FIGURE 17

FIGURE 18

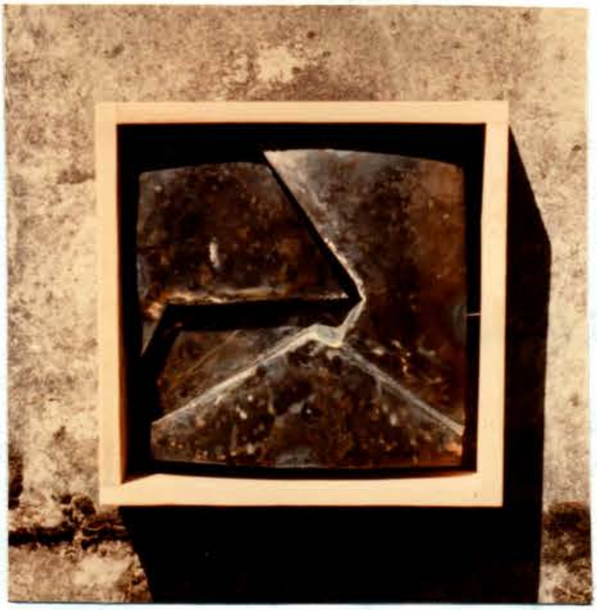

FIGURE 19

FIGURE 20

FIGURE 21

FIGURE 22

FIGURE 23

FIGURE 24

SCULPTURES BY THE AUTHOR

FIGURE 25
Plaster/vermiculite. H. 18"

FIGURE 26
Bronze. H. 15"

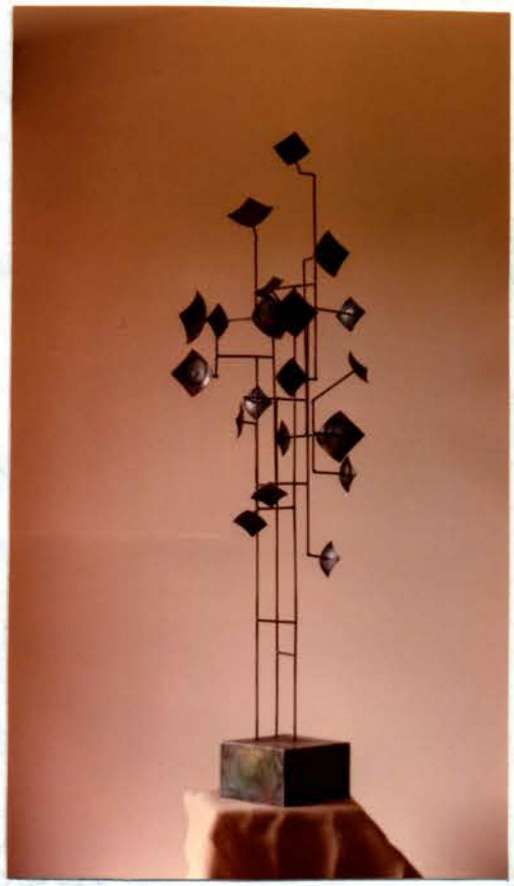

FIGURE 27
Steel. H. 38"

FIGURE 28

Bronze. H. 15"

FIGURE 29
Steel. 28" x 28"

FIGURE 30
Bronze. H. 7"

FIGURE 31

Steel. H. 12"

FIGURE 32
Steel. H. 17"

FIGURE 33

Steel. H. 24"

FIGURE 34
Plaster. 24" x 21"

FIGURE 35
Plaster. 28" x 28"

FIGURE 36

Steel. H. 21"

FIGURE 37

Steel. L. 15"

FIGURE 38

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