INTEGRATION OF BEARINGS IN KINETIC WELDED METAL SCULPTURE

A THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

FOR THE DEGREE OF MASTER OF ARTS

IN THE GRADUATE SCHOOL OF THE

TEXAS WOMAN'S UNIVERSITY

COLLEGE OF HUMANITIES AND

FINE ARTS

DEPARTMENT OF ART

BY

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DENTON, TEXAS

MAY, 1983

The Graduate School

Texas Woman's University

Denton, Texas

April 4 19 83

We hereby recommend that the thesis prepared under our supervision by Patricia Ann Eldridge entitled INTEGRATION OF BEARINGS IN KINETIC WELDED METAL SCULPTURE

be accepted as fulfilling this part of the requirements for the Degree of Master of Arts.

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ACKNOWLEDGEMENTS

The writer's interest in welded metal sculpture began at Texas Woman's University under the instruction of Mr. J. Brough Miller and Mr. Alfred Green both of whom offered technical knowledge and a great deal of encouragement. Much appreciation is extended to Mr. Robert Miller, Jr. and Mr. Tom Hutton. Mr. Robert Miller, Jr. introduced the writer to scrap metal cut by a cutting machine. The exciting forms that resulted or that could be created inspired the writer to experiment with kinetic sculpture. Mr. Hutton, a master machinist, worked patiently with the writer to solve complicated problems concerning the intricate machine work involved in the sculptures.

This thesis is dedicated to Mr. Thomas E. Eldridge, husband of the writer, whose gracious encouragement and physical help was vital to the completion of the writer's degree. Not only did he allow the writer to take an apartment in Denton for two summers, thus freeing her from duties at their home, but he also helped move over one thousand pounds of metal and/or sculptures each of the several times they had to be moved. He also spent many hours with the writer using a disc grinder to finish cut edges of the metal and welds on the sculptures. Kind assistance from all of these sources is very much appreciated.

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CHAPTER I

STATEMENT OF THE PROBLEM

The problem was to determine technical and practical methods of utilizing bearings to juxtapose stationary and moveable sections of welded metal sculpture through appropriate works to be developed by the writer.

PURPOSE OF THE STUDY

The purpose of the study was, by the use of various methods of incorporating bearings in kinetic metal sculptures, to create a unique art form enabling the viewer to become aesthetically aware of all aspects of such works.

RATIONALE AND JUSTIFICATION FOR THE STUDY

A. In a search conducted by the writer, very limited information was found concerning the technical problems involved in utilizing bearings in kinetic metal sculpture. Information that was found concerned primarily the life of the sculptor and the aesthetic contribution of his work.

B. The writer was motivated to investigate the feasibility of incorporating bearings to achieve movement within a welded metal sculpture.

C. Because of the excessive weight of some of the sculptures, the writer was successful in incorporating appropriate methods of disassembly for easy installation by two or three people.

D. The writer took advantage of modern technology by making use of scrap steel from tool and die companies that employ a cutting machine capable of cutting up to six inches of metal with computer accuracy. Bearings and bushings were used to incorporate movement. All movement within the pieces is at the discretion of the viewer. Motors, water or mechanical means were not employed.

E. Limited documentation concerning the final finish of the metal sculptures motivated the writer to find a means of preserving the rust-free sheen obtained by sandblasting and polishing with a disc grinder.

DELIMITATIONS

The study did not cover all possible uses of bearings in kinetic metal sculptures or utilize all types of bearings. The writer instead incorporated selected bearings and bushings which were integrated into the aesthetic design of the sculptures supporting the weight of the metal forms allowing them to move freely at the discretion of the viewer. The writer conducted the study according to the following delimitations:

I. The selection of the materials was based on the aesthetic judgment of the artist, local availability and reasonable cost with restriction of size and weight to allow for transportation. Basic materials included:

A. Scrap steel from a tool and die company that uses computerized cutting machines for cutting steel plate. Century Metals Corporation, Dallas, Texas was the primary source.

B. Structural angles, C channels, I beams, steel plate, bar stock, pipe and scrap steel. The sources were Fulton's Recycling Yard and Hoop's Machine Shop, Denton, Texas; Liberty Division Steel, Dallas, Texas; Garland Structurals Incorporated, Garland, Texas; and E. H. Mims Company, Dallas, Texas.

C. Bushings and bearings purchased from Tom Hutton, Industrial Truck and Machine Shop Service, and Bearing Chain and Supply, Inc., Dallas, and Denton Bearing and Supply, Inc., Denton.

D. Hex bolts purchased from Denton Bolt Co., Denton.

E. Welding electrodes from Texas Woman's University and Rite Weld Supply Co., Denton, Texas, consisting of the following:

1. E6011 welding electrode because of high penetration qualities into the base metal.
2. E6013 welding electrodes were used for fill welding.
3. E7018 welding electrodes were used for extra large fill welds.

II. The writer used the following tools:

A. Hand tools consisting of metal files, hammers, center punch, tap and die sets, pliers, vise clamps, hack saw, bench vise and adjustable wrenches.

B. Measuring devices consisting of sliding caliper, tri square, carpenter's square, tape measure, carpenter's protractor, micrometer calipers and combination square.

C. Hand power tools consisting of disc grinders, both 7 inch and 4½ inch, ½ inch drill, drill press, engine lathe, jig saw, electric arc welder, oxyacetylene cutting torch, horizontal band saw and heavy duty bench grinders.

III. The writer used the following resources:

A. Resource Persons:

Tom Hutton of Industrial Truck and Machine Shop Service, Dallas, Texas; Mack Thomas of Industrial Painting Company, Garland, Texas; Paul Hansen of Bearing Chain and Supply Inc., Dallas, Texas; and Don Heston of Trinity Industries, Inc., Dallas, Texas.

B. Resource Institutions:

Texas Woman's University Library, Denton, Texas, North Texas State University Library, Denton, Texas, Dallas Public Library, Dallas, Texas, Eastfield Community College Library, Dallas, Texas and Dallas Museum of Fine Arts, Dallas, Texas.

IV. The study and experimentation was done at Texas Woman's University, Denton, Texas and the writer's personal residence at Dallas, Texas.

V. The research was set-up within a budget of $1,500.00.

VI. At the conclusion of the research and experimentation the writer will present an exhibit of six kinetic metal sculptures.

DEFINITION OF TERMS

Bearings: Part of a machine which holds or supports moving parts and reduces friction and wear. (Macmillan Contemporary Dictionary, 1979, p. 84) Research on the part of the writer concerning the basic design of bearings revealed that bearings utilize either steel balls, steel cylindrical rollers or steel tapered rollers to minimize the friction and wear between two surfaces while supporting the moving parts of an object. These balls or rollers are usually spaced in a circle by a thin cage and are then sandwiched between two flat or grooved steel circles called races to comprise the bearing assembly. Bearings utilize this basic principal, but the variety of combinations of assemblies are almost endless depending upon the load, direction of thrust and the speed of travel needed for the specific problem. (Timken Engineering Journal, 1972, pp. 8-20)

Bushings: Replaceable metal liners used to lessen abrasion and wear or to decrease the internal diameter of either a pipe or a part into which another part fits. (Macmillan Contemporary Dictionary, 1979, p. 134) Bushings are manufactured from oil-impregnated bronze powder compressed under high pressure by a metallurgy process which provides uniformly distributed pores between the metal particles which absorb oil by capillary action. (Boston Gear Bearing Products, 1975, p. 139) The chief advantage of bushings is their self-contained oil supply and the fact that they do not rust.

Clearance-fit: The fitting of an internal member into an external member as a shaft in a hole with a certain degree of clearance or tolerance between the two parts. (Technical Drawings, 1974, p. 337)

Engine Lathe: A general purpose machine tool which is power driven and is used for producing cylindrical work pieces. As the piece of metal to be machined is rotated in the lathe, a single point cutting tool is advanced radially into the work piece to a specified depth and moved longitudinally along the axis of the work piece removing metal in the form of chips. Both inside and outside surfaces can be machined on a lathe. By using attachments and accessories other operations such as drilling, reaming, boring, taper and angle turning, knurling, milling, grinding and polishing may be performed. (Shop Theory, 1974, p. 172)

Fabrication: The process of manufacturing or constructing. (Macmillan Contemporary Dictionary, 1979, p. 365) For the purposes of this study the fabrication utilized mild steel (either found or processed by the writer) welded with either an arc welder or an oxyacetylene torch to create kinetic metal sculptures.

Kinetic: Of or relating to motion. (Macmillan Contemporary Dictionary, 1979, p. 565)

Races: The steel rings of an anti-friction ball bearing. (Macmillan Contemporary Dictionary, 1979, p. 823)

Radial Thrust Bearings: Bearings designed to carry loads acting perpendicular to the axis of the bearing. (Timken Engineering Journal, 1972, p. 8)

Steel: An alloy of iron and carbon. In addition there are minute percentages of other elements including silicon, phosphorus, sulfur and manganese. (Shop Theory, 1974, p. 517)

Tapered Thrust Roller Bearings: Bearings which, because of their tapered races, have the ability to carry both radial and thrust loads in any combination. (Timken Engineering Journal, 1972, p. 8)

Thrust Bearings: Bearings designed to carry loads applied parallel to the axis of the bearing. (Timken Engineering Journal, 1972, p. 8)

Welds, Basic Types: (Welding Technology, 1980, pp. 664 thru 691)

Back or Backing Weld: Used on the point side of a groove weld to fill in the back.

Fillet Weld: A triangular shaped weld that joins two surfaces at approximately right angles in a lap joint, tee joint or corner joint.

Groove Weld: A weld made in the groove between two pieces of metal. The types of groove welds are square, single vee, single bevel, single U, single J, double vee, double bevel, double U and double J.

Plug Weld: A circular weld made through a hole in one piece of a lap or tee joint joining that piece to the other. The walls of the hole may or may not be parallel and the hole may be partially or completely filled with the weld metal.

Surfacing Weld: A weld also known as buttering being a type of weld made with one or more stinger beads (weld made with little side to side movements) welded on an unbroken surface to give the surface different properties or dimensions.

CHAPTER II

BACKGROUND FOR THE STUDY

Until the twentieth century, sculptors were tied to conventional forms and materials. Their work was completely static, being molded, carved or cast. With the industrial age modern technology has freed today's sculptor to utilize new methods, unlimited materials and the introduction of mobility. Kinetic sculpture not only allows the viewer to respond aesthetically to the work, but the sculpture can respond to the touch of the viewer. Diane Chichura and Thelma Stevens in Super Sculpture state:

> Some say it is not art, yet the artist has always been that rare person who recognizes the potential in his environment and sees beyond his time. He questions, explores and makes aesthetic statements about his changing society. He uses modern technology to communicate his inner feelings about our multi-media age.[1]

The author's research revealed that the art of welding was an innovation developed during World War I and was a process that inspired several sculptors in the early 1900's. A Spanish artist, Julio Gonzalez, is credited as being the first to utilize the technique of welding in his sculptures. He was a welder for a Renault factory during World War I. Gonzalez introduced Pablo Picasso to the torch in 1930 and under his guidance Picasso produced a number of abstract metal sculptures in which iron scraps, bolts, screws, pokers, pot lids and springs were assembled much as he had used rope and newspaper in his college paintings. These innovative works of Picasso were an inspiration to the Russian artist, Vladimir Tatlin, whose sculptures reflected his fascination with the new machine age.

> His model for the Monument to the Third International (1919-20; the project was never executed) is, in principle, the most remarkable example to be found in our century of a union of all the arts in a total composition that embraces everything—sculpture, painting, architecture, cinematography, light, and, particularly, motion.[2]

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[1] Diane B. Chichura and Thelma K. Stevens, Super Sculpture (Dallas: Van Nostrand Reinhold Company, 1974), p. 15.

[2] A. M. Hammacher, The Evolution of Modern Sculpture Tradition and Innovation (New York: Harry N. Abrams, Inc., n.d.), p. 178.

Davis Smith, born in Decatur, Indiana, parallels Gonzalez in that he earned his living as a metal worker. During his trip to Europe in 1935 Smith was encouraged by the work of Gonzalez and Picasso to devote himself to metal sculpture. Theodore Roszak and Jose de Rivera also had industrial backgrounds.

Roszak uses the machine process and fabricating techniques to produce his sculptures which resembled beautifully engineered machines. Jose de Rivera, born in West Baton Rouge, Louisiana in 1904, combines traditional sculptural form with industrial materials. His main obsession is the effect of light on polished surfaces and the use of fluid shapes to create an inner volume. He incorporated physical movement into these forms, thus creating an illusion of light, space and movement. Much of Rivera's work is kinetic, but his forms simulate a drawing in space and the shapes that he welds are primarily forged. The writer's research did not reveal documentation of the methods used for movement; however, some are motorized.

Alexander Calder, trained as an engineer, was intrigued with the possibility of motion in his art and in 1931 had a show of mobiles. In fact, it was Marcel Duchamp who suggested that Calder call his sculptures "Mobiles". (Duchamp's sculptures utilized every day objects in combination with electrical and mechanical movement. Revolving Glass and Rotary-Demi Sphere, Precision Optics (built in 1920) utilized electric motors set in the base to create a "corkscrew effect" in their movement). In 1944 Calder began to construct architectural toys that moved. The mobiles that he created utilized intricate balance and swivels. The shapes were usually of aluminum and were set in motion by touch or wind currents. He experimented with motors as well as hand cranks in some sculptures. The Whirling Ear constructed for the Brussels Fair in 1958 is motorized. Many of his stabiles incorporated mobiles. The City and Clouds Over The Mountain are examples. In 1966 he exhibited black steel stabiles with aluminum mobile tops which he called "Totems".

The writer's research revealed several other sculptors who produced kinetic metal sculptures, but their forms differ greatly from those of the writer and the movement often involves the use of motors, magnets, electricity or balance. Some of the better known kinetic sculptors are mentioned below. No documentation was found concerning the use of bearings.

Jean Tinquely produces machines that draw and some that cast junk into space. Many of his sculptures solve one of the major problems inherent in kinetic sculptures, that of breakdown and supply of parts. They are designed to self-destruct almost immediately upon completion. Claes Oldenberg creates soft sculptures of common objects. Giant Icebag is an example of one that utilizes controlled jets of air to inflate and collapse. Soft Drainpipe is adjustable by the use of a pully. Salvatore M. Romano utilizes water for the movement of massive steel construction called Sliding Blue. Beverly Pepper's Contrappunto in New York is an eighteen foot steel structure. The bottom is stable and the top rotates every five minutes. Pol Bury utilizes hidden motors to create slow and mysterious movement in his sleek metal sculptures. Many of his sculptures incorporate electro-magnets. Len Lye in The Loop uses charged magnets to pull a loop of steel downward then releases it suddenly. The results are orbiting reflections and musical tones that pulsate in rhythm with The Loop. The Greek artist Vassilakis Takis uses electrical magnets that first attract, then go dead producing uncontrolled spasms among the wireless metal objects in his Telemagnets.

CHAPTER III

METHODS AND PROCEDURES

The writer's first attempt at kinetic sculpture was Alarendonda. The focal point of the sculpture, which is the 31½ inch pierced circle of 2 inch thick steel, seemed best suited to be free to turn on its base. The successful completion of this sculpture led the writer to pursue other attempts at kinetic sculptures and eventually the writing of this thesis.

The 31½ inch pierced circle was cut from a 2 inch thick steel skeleton of negative scrap shapes obtained from Century Metals Corporation of Dallas. The company uses computerized cutting machines for cutting steel plate up to 6 inches thick. Tool and die companies similar to this one are an excellent source for unusual shapes of scrap steel.

Construction for the base of the sculpture began after several preliminary drawings were made. The 24 inch tall section of the base was constructed from an 8 inch C channel which is 2¼ inches thick. The top section of the C channel was cut slightly concave to repeat the shape of the large circle to be mounted above. A 1½ inch pipe 12 inches in length was welded to the center of the C channel with 2 inches extending beyond the concave top of the base. Fourteen gauge steel was cut to fit the open side of the C channel and welded in place. Another piece was cut to fit the concave top section including a 2 inch diameter hole to fit the 1½ inch pipe. This piece was welded in place and all welds were ground smooth. Six plug welds were used to secure the pipe inside the base.

In order for the sculpture to stand erect and support the weight of the 31½ inch pierced circle, modifications had to be made to the weight and width of the base. The foot of the base is a 1 inch steel plate 14 inches by 21¾ inches. Slot welded to this rectangle is a piece of 2 inch steel fashioned to fit inside the C channel base. This section is 7½ inches in width and 10 inches in height and weighs 75 pounds. This assembly was not welded to the C channel section of the base in order to allow for easy disassembly when the sculpture is moved.

The final step in completing the sculpture was to fillet weld a 10 inch long 1½ inch steel rod. This had been beveled at the point of the weld to allow for maximum penetration and strength, and added to the bottom of the 41 inch pierced circle. A Torrington FNT 4060 thrust needle roller bearing was selected because of its weight tolerance and its thickness, which is only .175 inches including two washers. The writer machined a cap to cover the bearing to protect it from moisture. See Figure 1 for details of the bearing section of the sculpture. The sculpture was then sandblasted by Denton Monument Company, ground to a sheen with a disc grinder and then sprayed with two coats of Sherwin-Williams clear polyurethane with an outdoor catalyst by Superior Industrial Painting Company of Garland, Texas.

Fig. 1 Photograph of Alanrendona

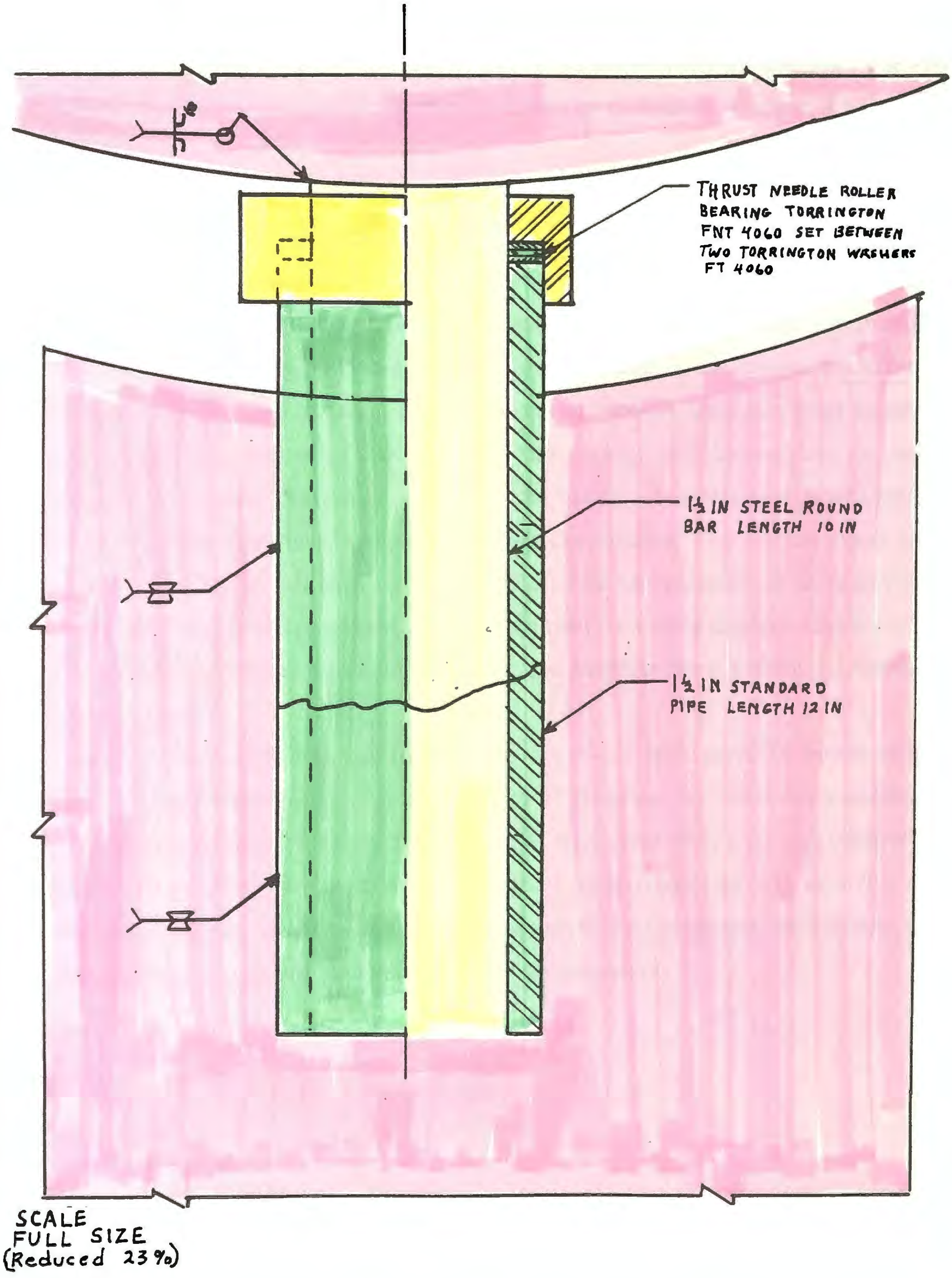

Fig. 2. Detail of Bearing Section of <u>Alarendona</u>

The sculpture Spectrum allows two shapes to move freely on the base. The viewer may rotate the shapes independently at will. Once the movement is begun it will continue for several minutes.

The major elements of this sculpture are the two large shapes of 2 inch thick steel which were found in the scrap bin at Century Metals Corporation. One is a 24 inch pierced circular shape and the other is a 45 inch square with rounded corners. It has a 31 inch circle cut from the center. The overall conception of the sculpture was immediate but the solution was not. The writer tried to incorporate solutions utilized in the sculpture Alarendonda; however, the shapes were different and the spaces in between were too short to allow for stability. Much trial and error led the writer to consult with a machinist in order to complete the sculpture. The writer was advised to have a center section removed from each of the pieces. This was done by Century Metals Corporation. This section would then be replaced by a section of 2¾ inch steel rod which could be machined on an engine lathe to house the bearings. These machined pieces could then be welded in place. (Refer to Figures 2 and 3.) Mr. Tom Hutton of Industrial Truck and Machine Shop Service did the machine work for Spectrum.

The base section was constructed from a 6-5/8 inch pipe, 36 inches in length, welded to a shape cut from one inch steel plate 21 inches at its widest point which in turn was welded to a 23 inch circle cut from 1/2 inch steel plate with a 20 inch circle removed from the center. When all parts of the sculpture were completed and all welds ground smooth, the sculpture was finished in the same manner as Alarendonda, sandblasted, ground to a sheen with a disc grinder and coated with clear polyurethane.

Fig. 3 Photographs of Spectrum

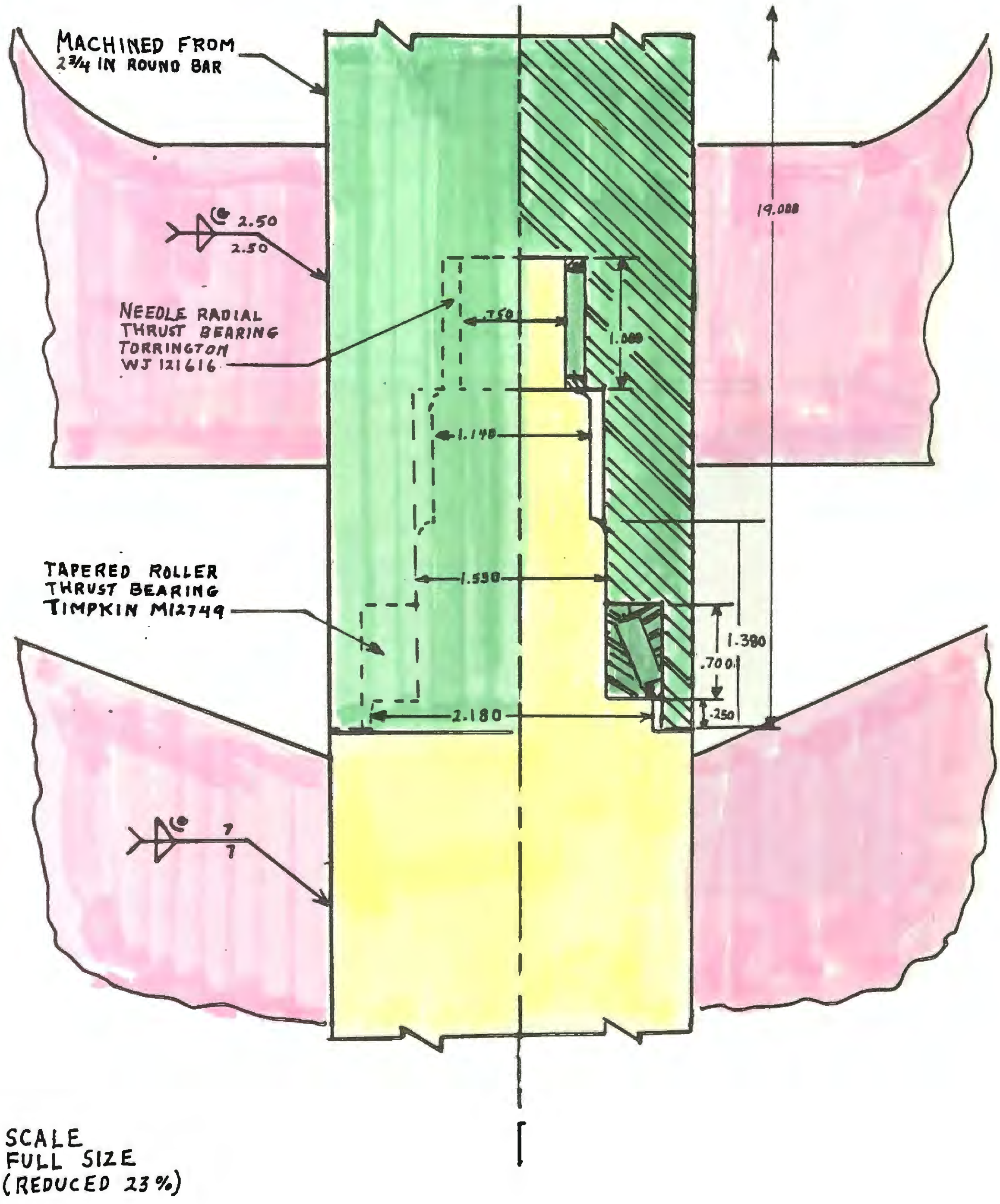

Fig. 4. Top Section of Spectrum

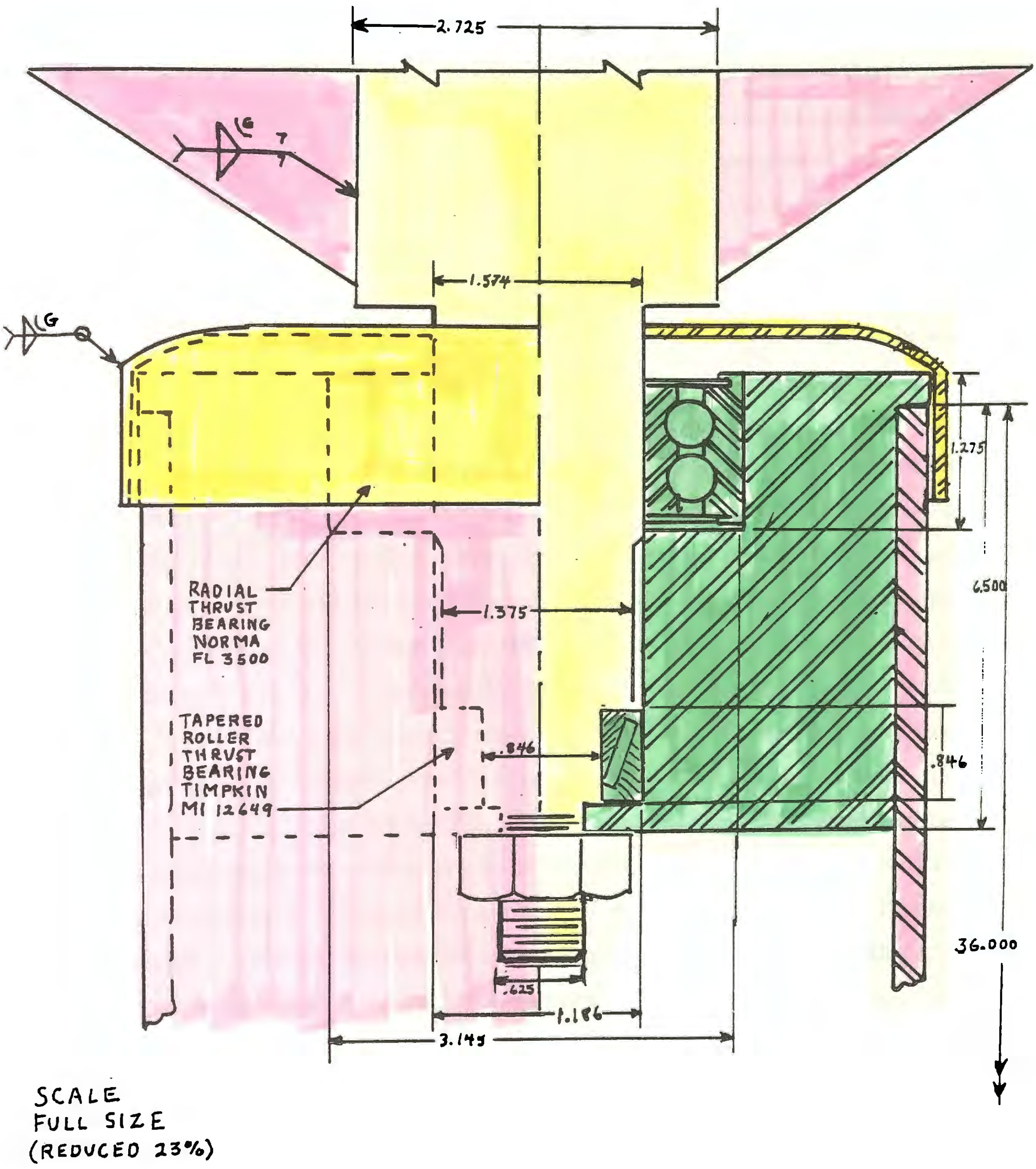

Fig. 5. Base Section of Spectrum

The sculpture Semilla Vaina was inspired by the discovery of four unusual shapes of metal each 15½ inches in length and 3½ inches in width. When welded together at a 90 degree angle, these shapes reminded the writer of the stamen of a flower. A top portion was also fabricated from metal of the same shape. Four petal shapes were then constructed from eight curved rods from a hay rake and 16 gauge sheet steel. Each petal was formed from two curved rods, each 30 inches in length. These were welded together at each end with a 6 inch spread in the center. Paper patterns were cut to fit the resulting shapes inside and out. The shapes were then cut from 16 gauge metal and were welded in place. The edges were ground smooth. The base of each petal was welded to a 1 inch pipe 1 inch in length to be inserted into a bearing assembly attached to the base. Five 8½ inch squares of 7 gauge scrap steel comprised the base.

All of the elements of the sculpture were ready for assembly. Movement was the primary consideration of the artist. The second criteria was the concealment and water-proofing of the bearings. The writer tried standard pipe, rods and bearings with bushings, but most parts needed to be machined to work properly. After much trial and error the only solution was to call upon the expertise of a machinist to machine the necessary parts to fit the writer's aesthetic design. At the time Semilla Vaina was constructed, the writer was not trained to use an engine lathe. The frustration of having to have some one else do machine work that could be done on the engine lathe at Texas Woman's University led the writer to take a special studies course in industrial arts to learn the basic principles of operating an engine lathe. The writer did machine a cap for one of the bearings that otherwise would have been exposed to water. This is illustrated by the green section in Figure 6. Detailed drawings of each of the three kinetic sections of this sculpture give the exact specifications of the machined sections of the sculpture.

Fig. 6. Photograph of Semilla Vaina

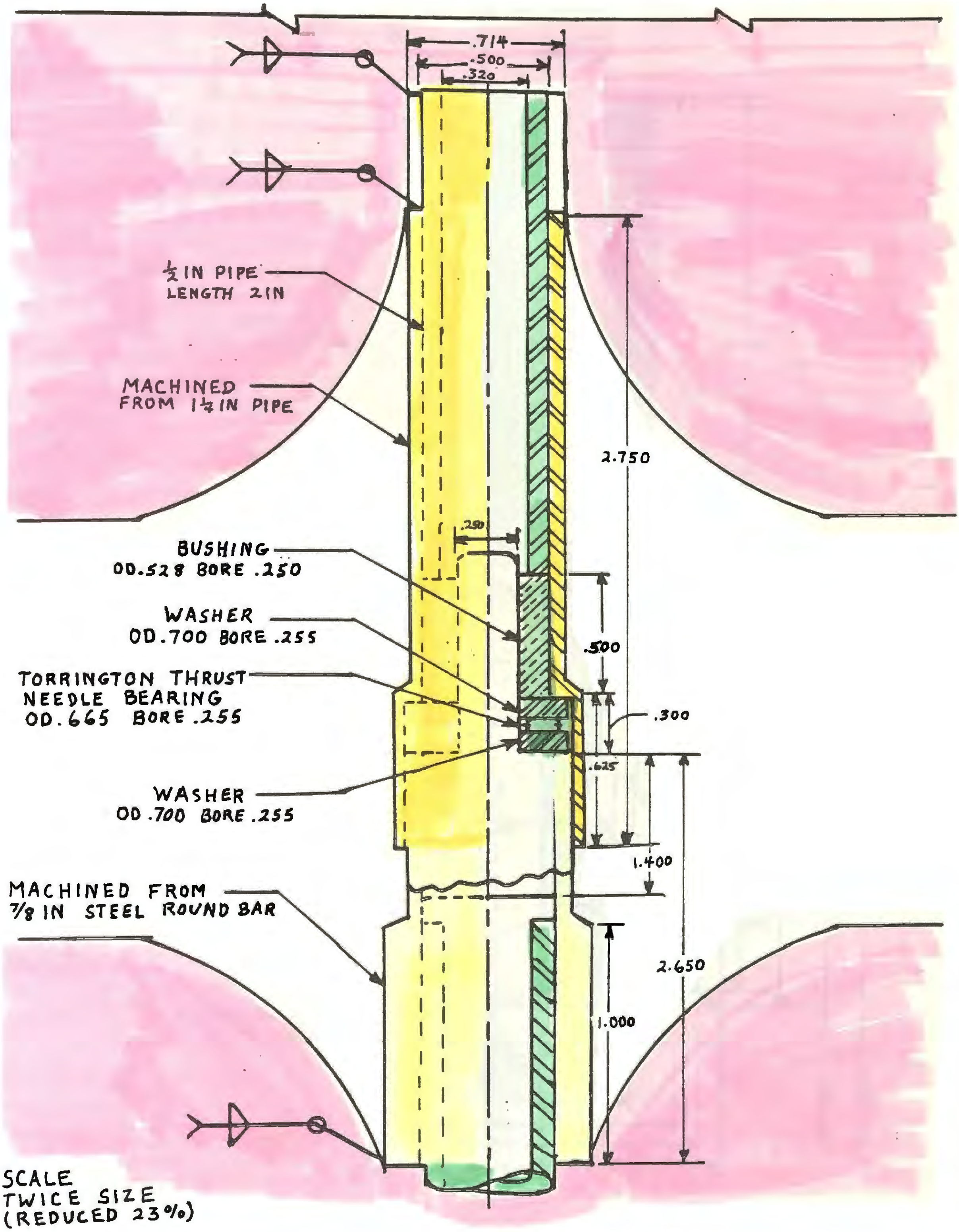

Fig. 7. Top Section of Semilla Vaina

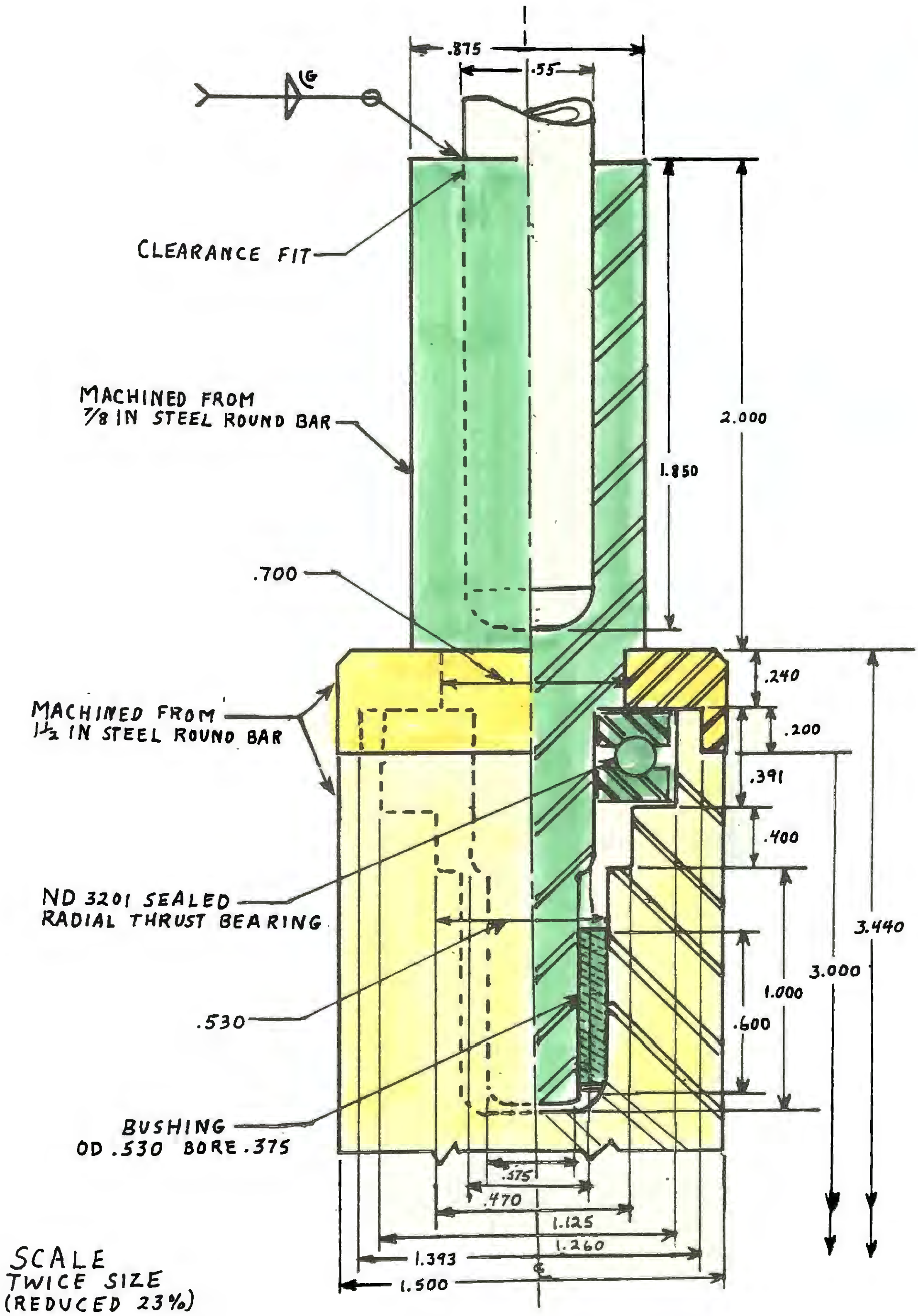

Fig. 8. Middle Section of Semilla Vaina

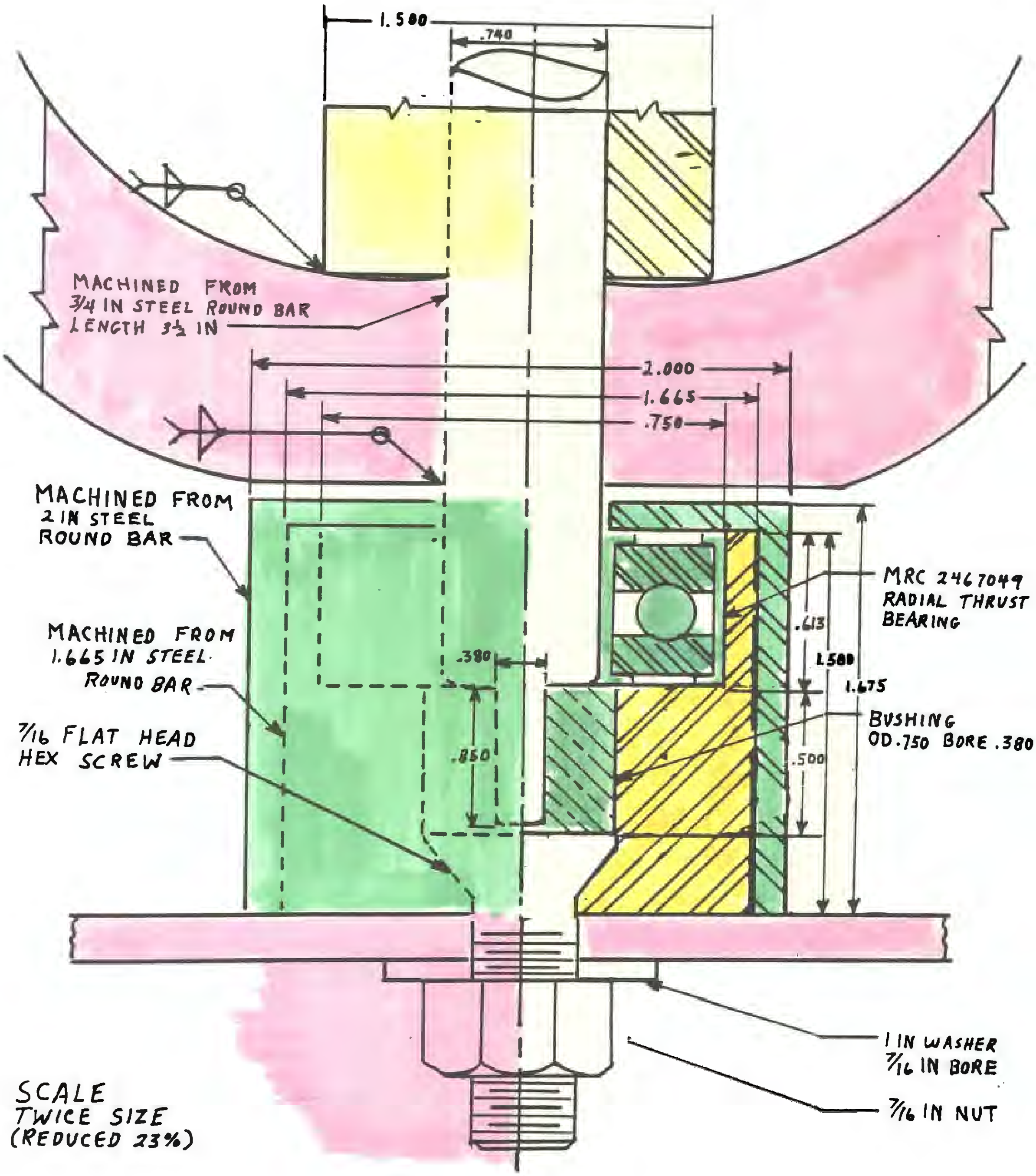

Fig. 9. Base Section of Semilla Vaina

The sculpture Lunar 1 was designed by welding many pieces of scrap steel into a variety of shapes. The letter 1 became the focal point of the design elements as all of the parts were combined. Great care was taken to insure that the sculpture was aesthetically pleasing from all points of view. The 36 inch circle that encompasses the abstract shapes completed the lunar theme. It seemed appropriate that Lunar 1 revolve on its axis; therefore, the base was designed to enable the viewer to rotate the sculpture at will. A detailed drawing of the base follows. The writer was extremely careful in being certain that all parts were precisely placed within .001 of an inch. A level and tri square were used to insure that all parts were squared as they were welded in place. If any part was not perfect, freedom of movement would be impossible. In a later sculpture the writer improved upon the design of the metal pieces holding the bearings in order that they can be adjusted in case the welds were not perfect. Compare Figure 7 of Lunar 1 with Figure 8 of Pipe Dreams.

Fig. 10 Photographs of Lunar 1

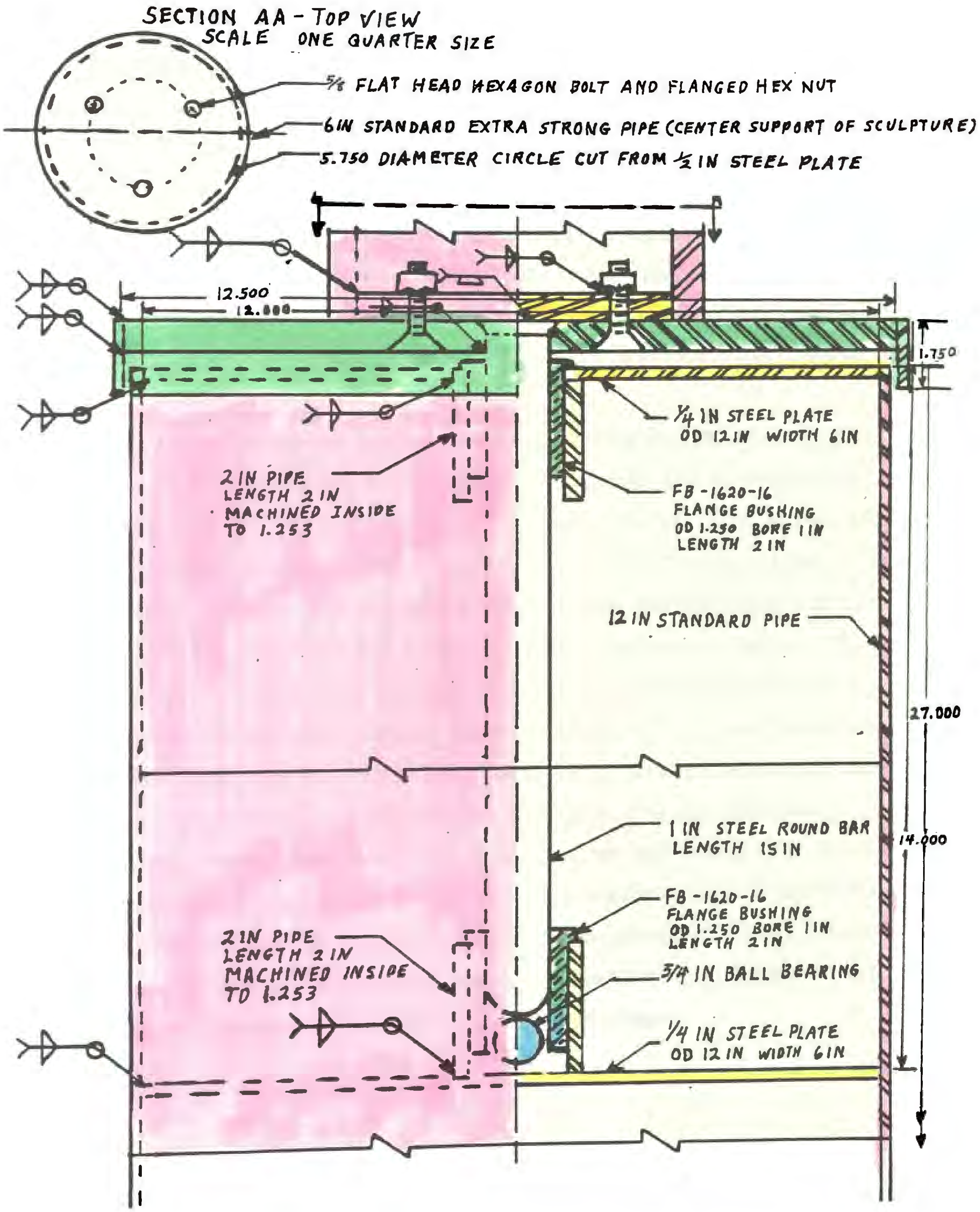

Fig. 11. Base Section of Lunar 1

Pipe Dreams is the artist's fantasy of smoke rings. The rings are constructed from varying sizes and thicknesses of pipe cut and welded so that they twist and turn into flowing shapes. The rings are held suspended by a cutaway section of 11 inch tubing 30 inches long. This section of the sculpture was completed in 1980, but was one of the last to be positioned on a kinetic base. In 1982 the writer had the sculpture sandblasted by Denton Monument Company, then proceeded to grind the rough edges of some of the rings with a disc grinder. At this point the sculpture began to show promise, but it did not gain its present stature until it became an intricate part of the base which was constructed of 11 inch tubing.

The ring section of the sculpture was constructed entirely of scrap steel. At that point in the construction the writer did not appreciate the importance of standard measurements used for various types of pipe, standard and thick wall, as well as for tubing which is still another category of sizes. The writer found that the original scrap of what was thought to be pipe was not pipe but tubing. This discovery was made after trips to five scrap yards and the ultimate discovery of E. H. Mims Company of Dallas. This company specializes in scraps of all sizes of thick wall pipe and tubing. They keep a complete up-to-date inventory and one telephone call will tell one if they have the specific pipe or tubing needed. They also use a horizontal band saw to cut the exact length requested. If more than one cut is needed a reasonable fee is charged. It is the experience of the writer that most scrap yards do not make cuts. Otherwise they will charge a fee for on-the-spot cuts with an oxyacetylene cutting torch if the order is large enough to require this service.

The base consisted of 11 inch tubing 36 inches in length. The writer used the same basic bearing movements as used in Lunar 1 illustrated by Figure 7 with certain modifications for alignment of the shaft as illustrated in Figure 8.

Fig. 12 Photographs of Pipe Dreams

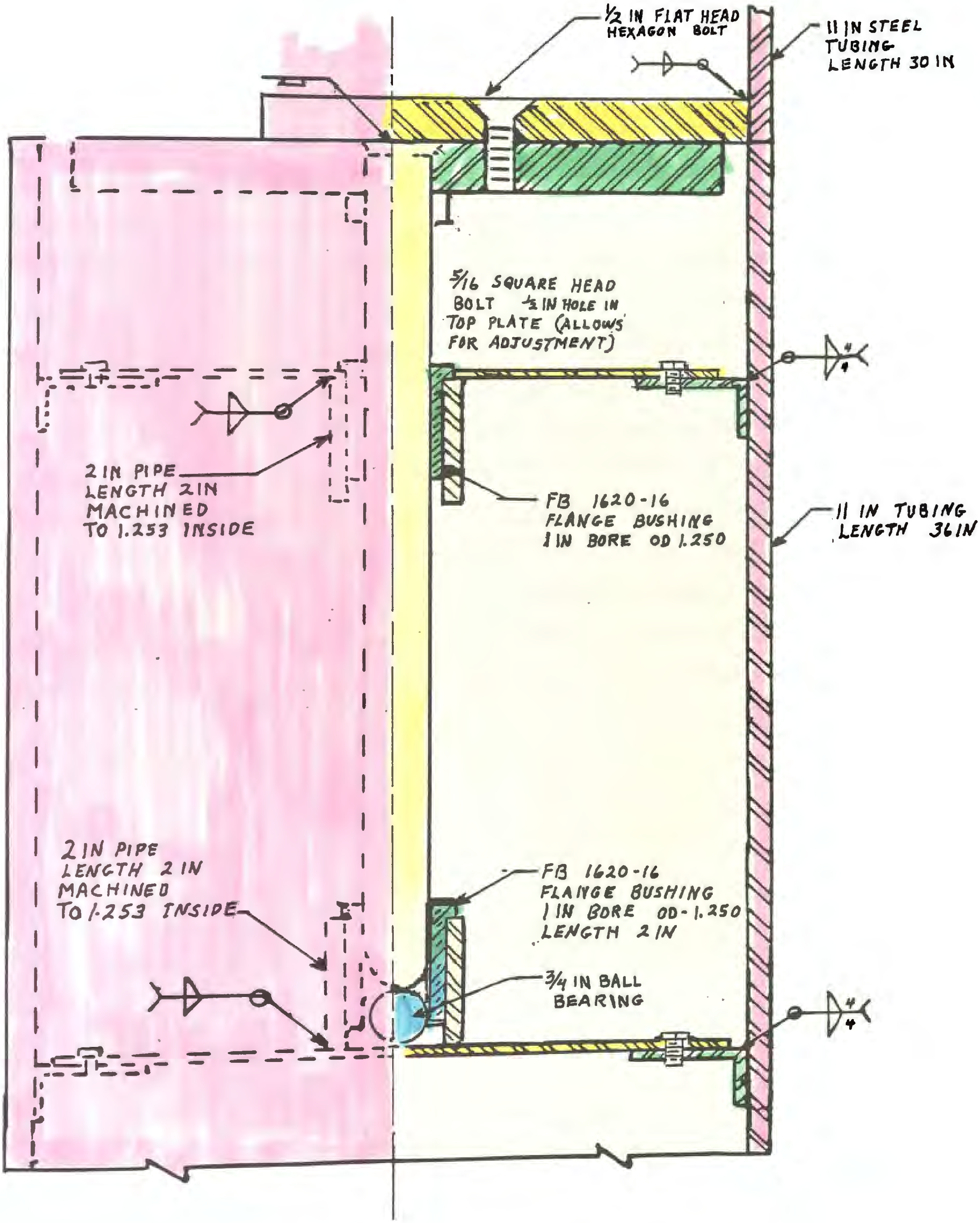

Fig. 13. Base Section of Pipe Dreams

Examples of the writer's first attempts at arc welding are included in the sculpture Black Gold. The top section of this sculpture utilizes a wide variety of scrap steel shapes welded together. The base section was constructed from a 12 x 5 inch structural I beam 36 inches in length. Shapes were cut in the I beam with an oxyacetylene cutting torch to correspond to the general contours of the top.

For three years Black Gold was the focal point of the writer's patio. Also during that time the writer's skills as a metal sculptor increased and it soon became apparent that certain changes would enhance the aesthetic quality of the sculpture. The sculpture received a thorough overhaul primarily through reinforcing some of the welds. The overall appearance was improved by grinding the rough edges of various sections with a disc grinder. The total sculpture was then placed on a kinetic base constructed from a 20 inch pipe 21 inches in height. (Refer to Figures 9 and 10 for the exact specifications.) The sculpture required one other change to tie it together as an aesthetic unit. The visual image of the 2½ inch rim around the base needed to be repeated within the original sculpture. Therefore, a metal band 2 inches in width was welded between the top section and the I beam and ground smooth. Black Gold thus became one of the sculptures included in this thesis.

Fig. 14 Photographs of Black Gold

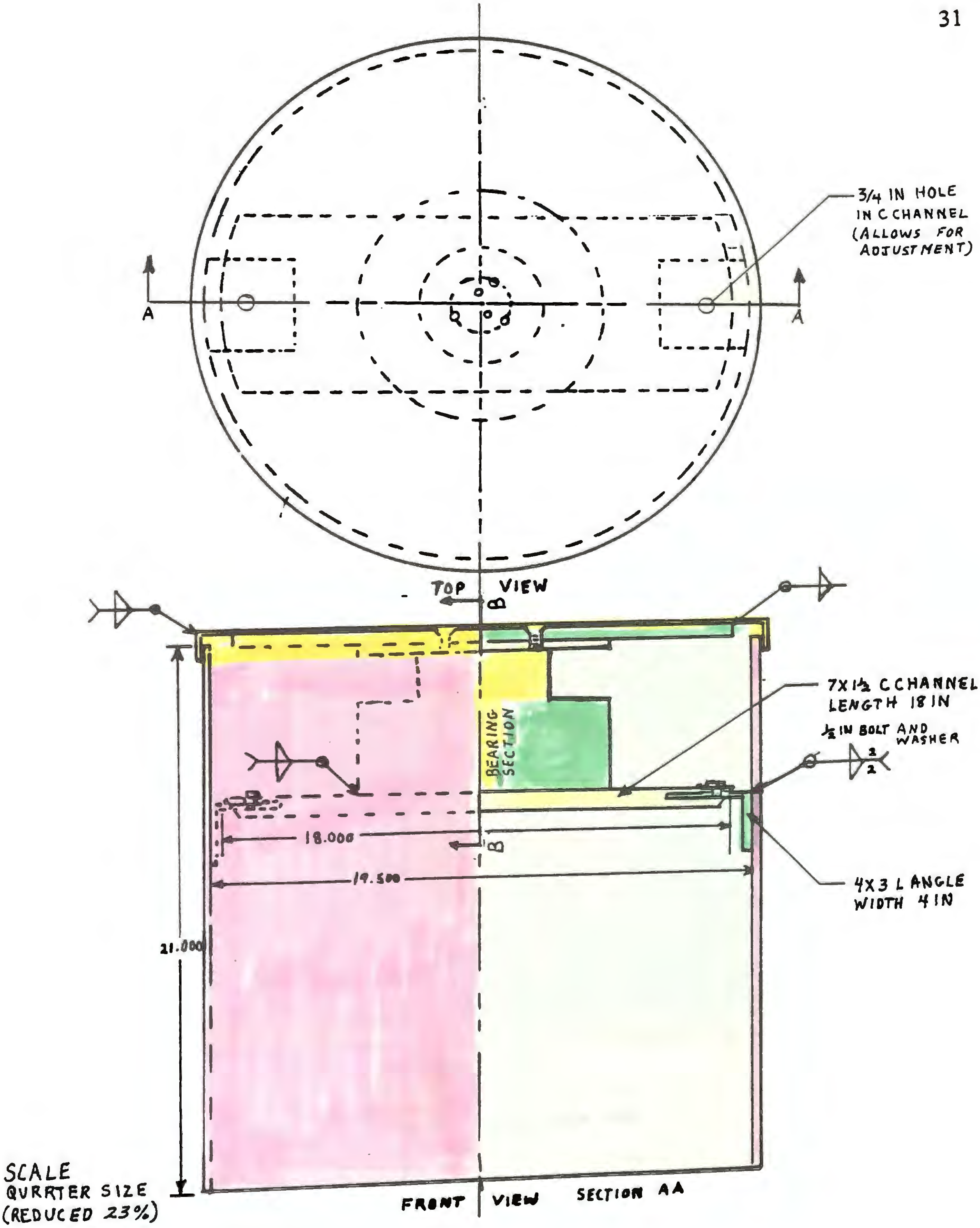

Fig. 15. Top View and Section AA of Black Gold

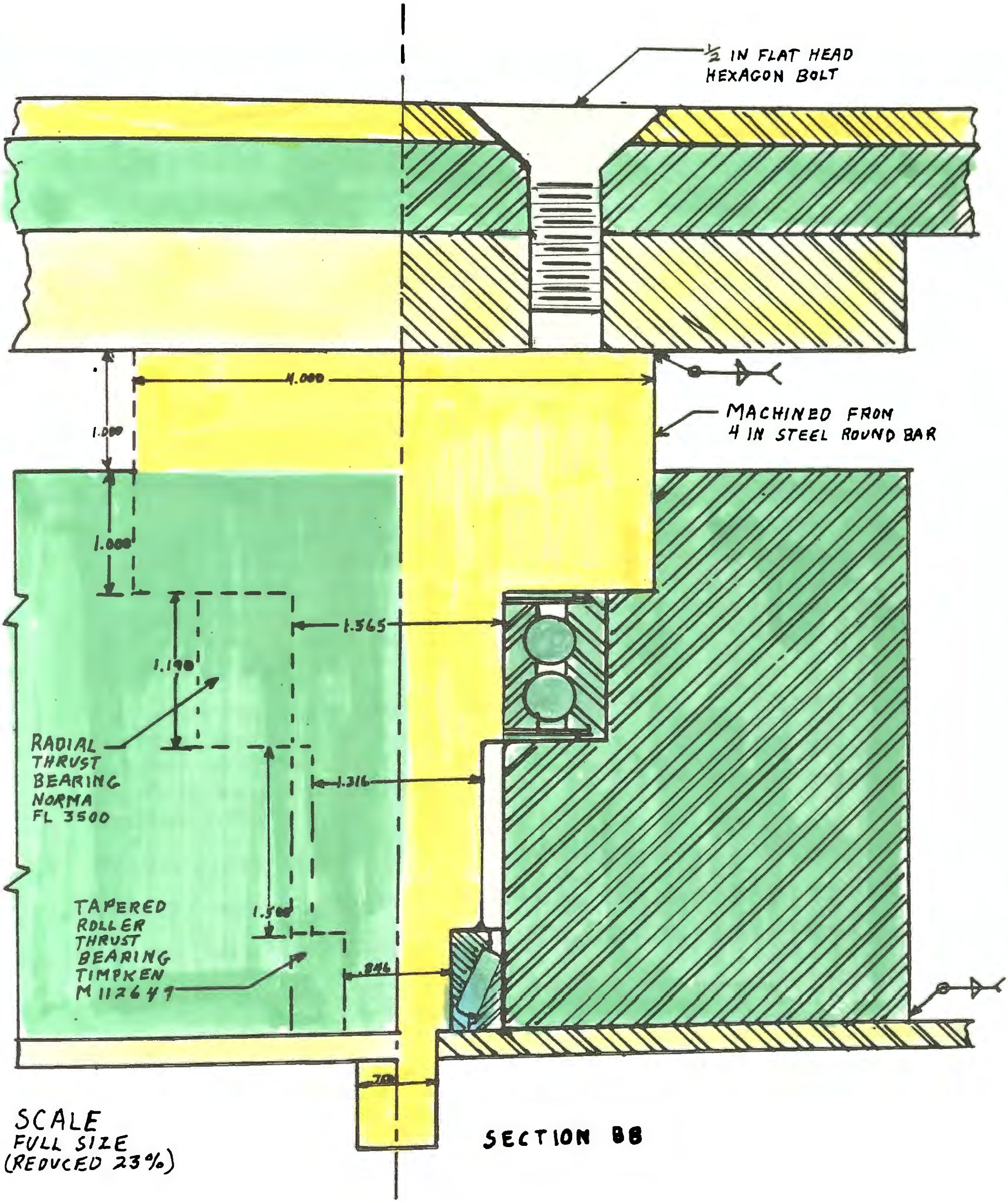

Fig. 16. Section BB of Black Gold

CHAPTER IV

CONCLUSIONS

At the onset the writer's interest in kinetic metal sculpture was sparked by the desire to enable the viewer to easily move the sculpture and become aesthetically aware of all viewpoints. It was an exciting experience for the writer to witness the fulfillment of this objective by watching viewers confront four of her kinetic sculptures in the Second Annual Art Educators Exhibit at Northlake College in April of 1981. The viewers usually expressed amazement that certain parts of the sculpture were moveable. They would then become engrossed with all aspects of the sculpture's various parts. Some comments expressed were:

> Your sculptures have created interest all over the campus. At times I would walk into the gallery when no one was there, but one of your sculptures would be in motion evidencing that some one had just been there. All of the comments I have heard have been extremely complimentary. Some students have inquired to see if metal sculpture is being taught at Northlake. (Marty Ray, Ceramics instructor at Northlake College).

> I am very impressed with your sculptures and was very surprised to know they were done by a woman. They are so massive and the precision of movement definitely requires someone well versed in the art of machine work and fabrication. (Dr. Gary Swain, Department Chairman of Humanities and Communication at Northlake College)

The development of aesthetically pleasing kinetic metal sculptures posed three major problems for the writer: (1) knowledge of the various types of bearings and their specific uses; (2) the fact that most standard size pipe and rods must be machined on an engine lathe to fit or house the bearings used in kinetic sculptures; (3) the complete assembly of the bearings must be housed within the sculpture in such a way as to be oblivious to the viewer and/or add to the aesthetic quality of the sculpture.

Research revealed that there are approximately one hundred and twenty well known companies in the United States that manufacture bearings. Each company tends to specialize in developing bearings designed for a specific industry and function. Examples follow: Boston Gear, whose bearings are designed for use in gear assemblies in power transmissions; Timken Bearing Company manufactures tapered roller bearings which, because of their tapered races, have the ability to carry both radial and thrust loads in any combination; Andrews Bearing Corporation specializes in thrust bearings, both steel ball and steel roller used in hydraulic jacks and pumps, industrial machinery and equipment. The writer found Paul Hansen of Bearing Chain and Supply Company of Dallas and Tom Hutton of Industrial and Machine Shop Service of Dallas most helpful in selecting bearings with the specialized capabilities required to insure free movement and hold the weight of specific sections of a particular sculpture.

The writer's background in art education, which began in 1959, was a distinct advantage in solving the aesthetic problems of each sculpture; however, her lack of knowledge regarding metal machining and fabrication created a definite problem in solving the technical and mechanical problems intrinsic in each sculpture, resulting in much trial and error. Because of the excessive amount of machining required in the kinetic sculptures, it seemed imperative that the writer needed to be able to operate an engine lathe. In order to accomplish this goal, the writer enrolled in a special problems course conducted by the Industrial Arts Department at The North Texas State University. Another benefit gained from this course was acquiring useful information concerning measuring devices, special tools and other machines especially designed for metal work. Many mistakes would have been avoided had the writer taken metal-related industrial arts courses earlier in her study. Ideally, metal sculpture should be taught in conjunction with a well equipped industrial arts department. Examples of sculptors who expressed their artistic creativity in a media that they knew well through an industrial background in working with metal are David Smith, Theodore Roszak and Jose Rivera previously referred to in this paper..

The excessive weight of five of the sculptures required appropriate methods of disassembly for easy installation by two people. In each of the sculptures the juxtaposition of the moveable parts by the use of bearings created the logical place for disassembly. It is, however, necessary to use a hoist or two additional people to easily move and install the sculptures. Experience has inspired the writer to be more aware of the weight and disassembly problems in future sculptures.

The sculptures entitled Spectrum and Alarendonda exhibit the writer's attempt to preserve the rust-free sheen of metal obtained by sandblasting and polishing with a disc grinder. The two sculptures were sprayed with two coats of Sherwin-Williams clear polyurethane with an outdoor catalyst by Superior Industrial Painting of Garland, Texas. The writer was certain no rust was apparent on the sculptures before the finish was applied. The sculptures maintained their rust-free sheen for approximately two months after which time dark stains of rust began to appear everywhere the metal was touched by human hands. At the time of this writing, it seems apparent that the sculptures will turn a rust color, but maintain the sheen and smooth feel of the epoxy coating.

Stainless steel and aluminum are rust-free metals that challenge the writer at a future date. When working with steel the most logical finishes are natural rust or paints designed for use on metal such as those used in the automobile industry. It is the opinion of the writer that paint of any color detracts from the quality of the metal. It also calls for maintenance within a few years, especially if the sculptures are subjected to weather conditions. The most practical solution therefore seems to be natural rust.

In kinetic sculptures special care must be taken to prevent rust in the areas where movement takes place. This must be done by designing the sculpture in such a way as to insure that water is repelled from the areas that contain the bearings and bushings. This may be accomplished by designing caps to cover the area and coating the moveable parts with a good quality of bearing grease.

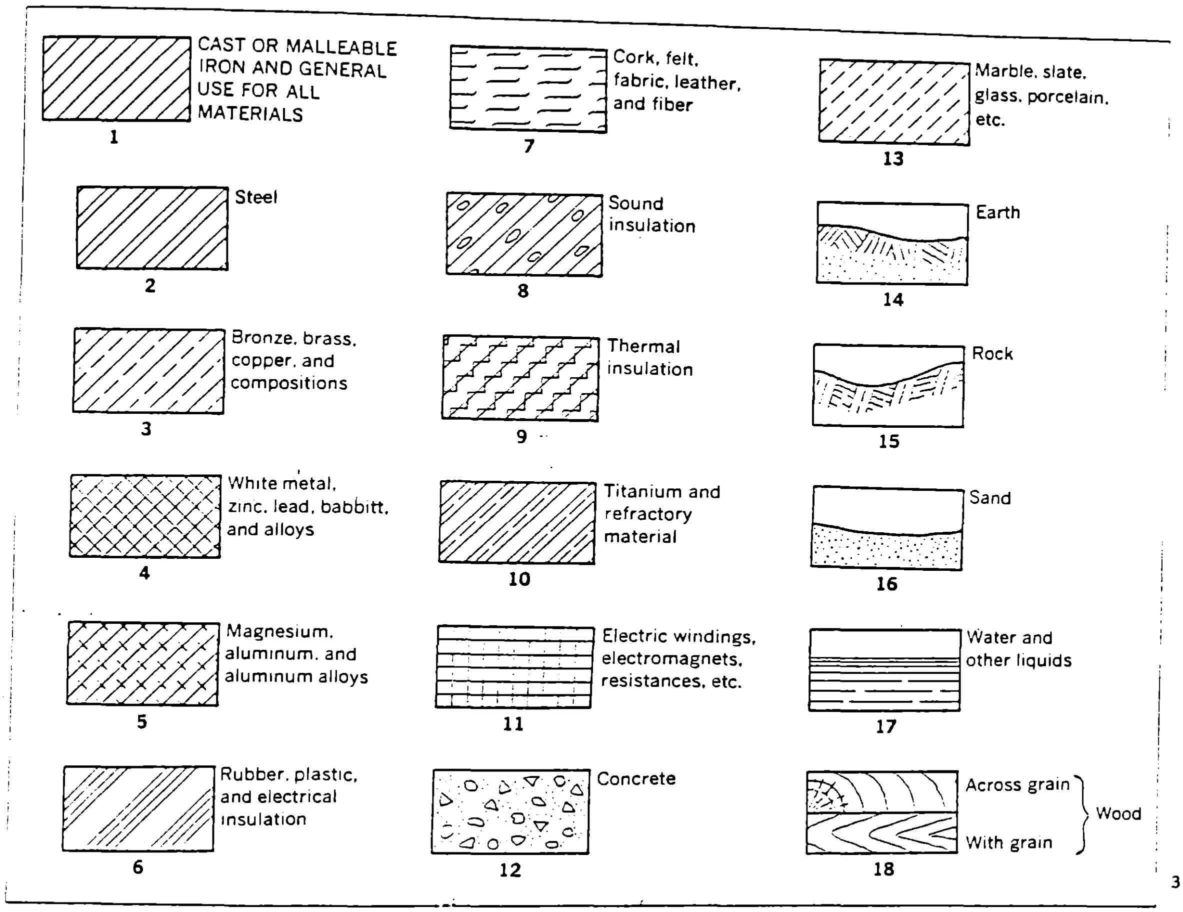

Fig. 17. Symbols for Section Lining

[3] Frederick Giesecke et al. Technical Drawing (New York: Macmillan Publishing Co., Inc.) p. 22.

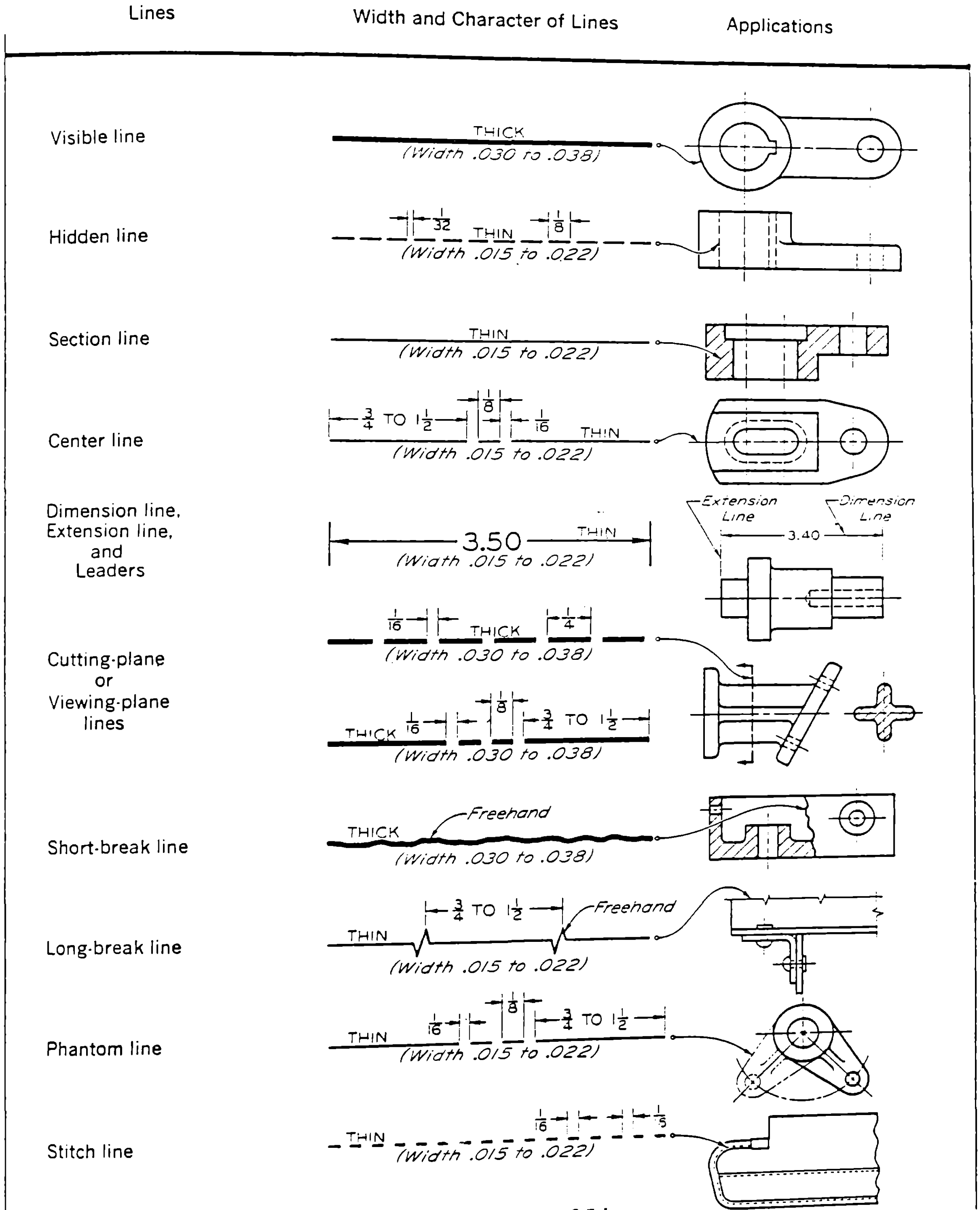

Fig. 18. Alphabet of Lines[4]

[4] Ibid., p. 22.

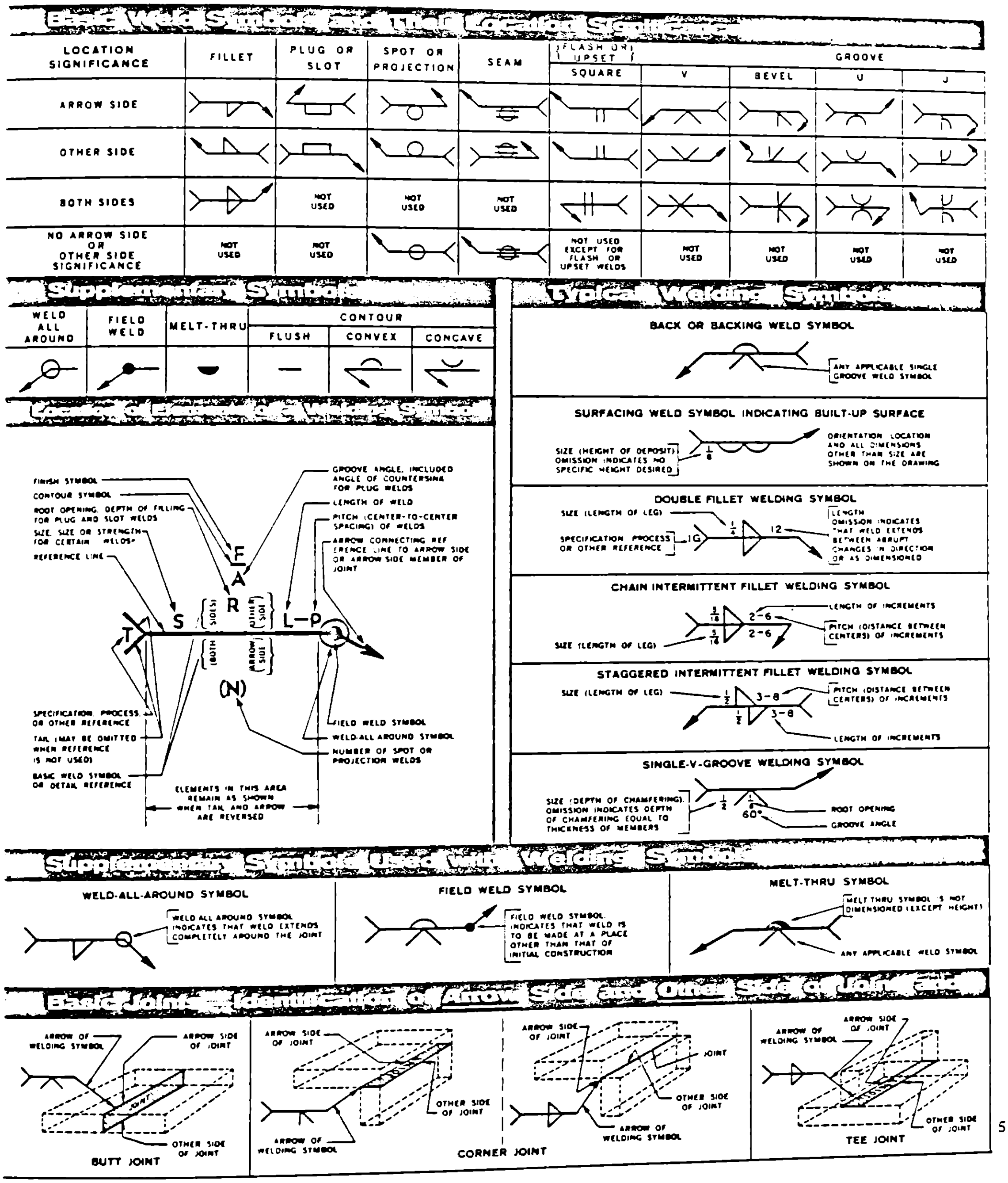

Fig. 19. American Welding Society Standard Welding Symbols

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[5] Ibid., p. 834

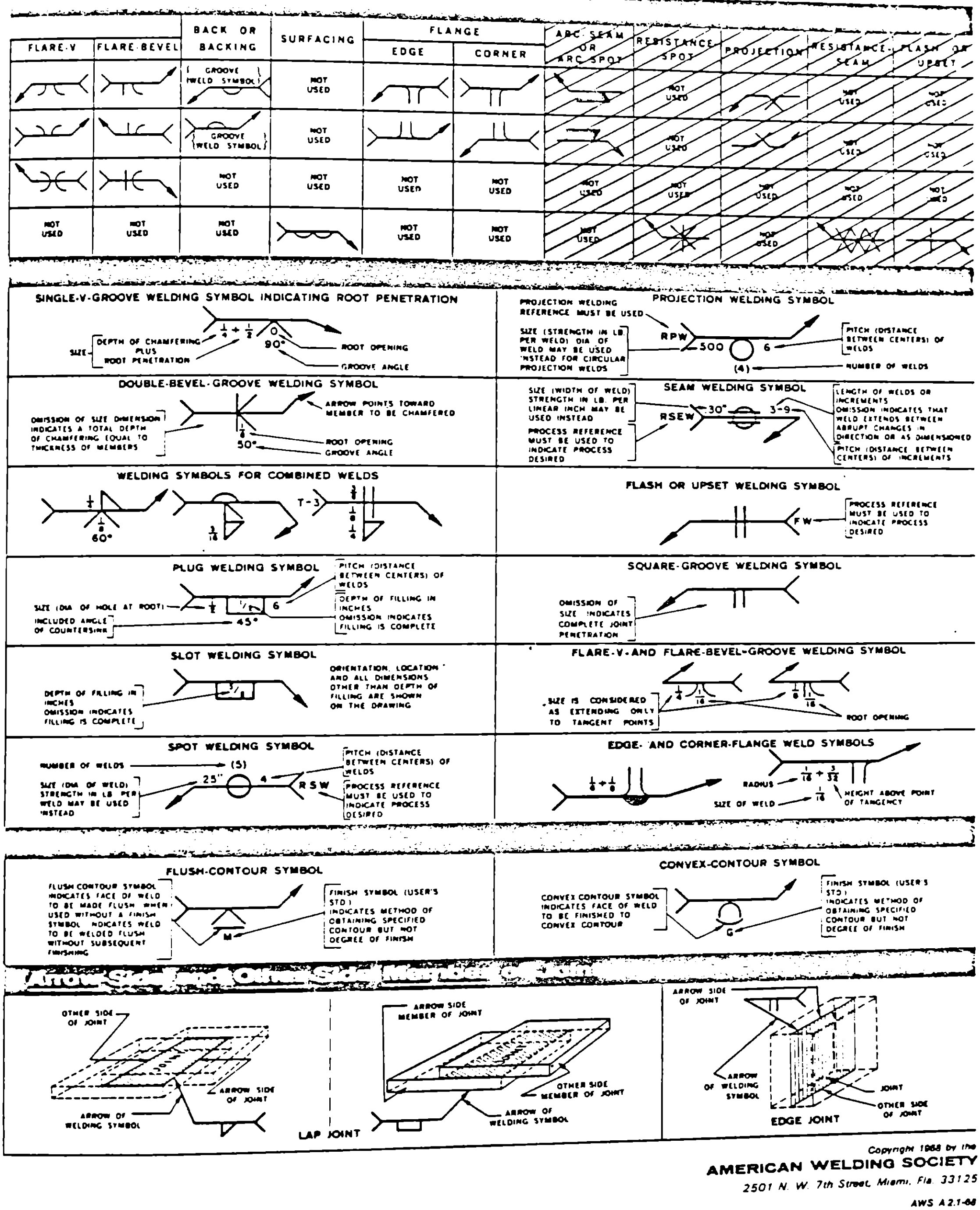

Fig. 20. American Welding Society Standard Welding Symbols (continued)[6]

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[6] Ibid., p. 835

BIBLIOGRAPHY

Anderson, James and Tatro, Earl E. Shop Theory. New York: McGraw-Hill Book Company, 1974.

Anderson, Wayne. American Sculpture In Process 1930-1970. Boston: New York Graphic Society, 1975.

Andrews Bearing Corporation. Andrews Thrust Bearings Catalog 4-250. U.S.A.: MPB Corporation, 1978.

Boston Gear Works. Boston Gear Bearing Manual No. BP75. U.S.A.: Boston Gear Works, 1975.

Calder, Alexander. Calder An Autobiography With Pictures. New York: Pantheon Books. Division of Random House, 1966.

Chaplin, Jack W. Metal Manufacturing Technology. Bloomington: McKnight Publishing Company, 1976.

Chichura, Diane B. and Stevens, Thelma K. Super Sculpture. Dallas: Van Nostrand Reinhold Company, 1974.

Coe, Ralph T. Dale Eldred Sculpture Into Environment. Lawrence: The Regents Press of Kansas, 1978.

Hammacher, A. M. The Evolution of Modern Sculpture Tradition and Innovation. New York: Harry N. Abrams, Inc. n.d.

Hulten, Pontus. Jean Tinguely Meta. Boston: New York Graphic Society, 1975.

Kennedy, Gower A. Welding Technology. Indianapolis: Bobbs-Merrill Educational Publishing, 1980.

Lipman, Jean. Calder's Circus. New York: E. P. Dutton, 1972.

Robinette, Margaret. Outdoor Sculpture Object and Environment. New York: Watson-Guptill Publications, 1976.

Smith, David. David Smith. New York: Holt, Rinehart and Winston, 1972.

Strachan, W. J. Towards Sculpture. Colorado: Westview Press, 1976.

The Timken Company. Timken Engineering Journal. U.S.A.: The Timken Company, 1972.

The Torrington Company. Torrington Bearings Catalog 478. U.S.A.: The Torrington Company, 1977.

TRW Marlin-Rockwell Division. MRC Bearings Industrial Service Catalog Form 382-10. U.S.A.: TRW Marlin-Rockwell Division, 1976.

Whitney Museum of American Art. 200 Years of American Sculpture. New York: David R. Godine Publisher in association with the Whitney Museum of American Art, 1976.