A COURSE OF STUDY IN
OXY-ACETYLENE AND ELECTRIC WELDING
WITH TEACHING AIDS

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By

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C. B. A.

TABLE OF CONTENTS

A COURSE OF STUDY IN OXY-ACETYLENE AND ELECTRIC WELDING WITH TEACHING AIDS

In the preparation of this study it is recognized that welding is both a trade and an industrial process, and that its influence is felt in every industry and occupation using metal as a basic material of construction. This study has been produced for the purpose of outlining the desirability of including a course of welding in the high school industrial arts curriculum.

Description of the Study

This study contains a history of oxy-acetylene and electric welding with related information concerning other welding processes. A selected bibliography is given including many of the best textbooks and reference books available at this writing, as well as a list of periodicals currently published. A minimum list of equipment for the installation and operation of a high school welding shop is included with Oklahoma sources of supply.

Practices change rapidly in an ever expanding field such as welding, which means that in order for the instructor to maintain a knowledge of the latest developments, and to profit from current research, a source of supply of such information must be at his command. Some of the best sources of materials are given in this paper; however, it must be kept in mind that new channels of information are becoming available, and the progressive instructor must study much to be informed.

Delimitations

Welding classes in high school should be made up of boys in the

with the hazards involved in the use of welding equipment. It is recommended that a two hour class period be provided for all high school welding courses.

The History of Welding

In view of the many applications of oxy-acetylene and electric welding in use today, it is difficult to realize that the entire commercial development of welding has taken place within the scope of the past seventy years. Before that time pieces of metal to be joined were heated to a plastic state in a forge, and then welded together by pounding. Forge welding, which is the name for this means of joining metal was very limited in its application, causing men to seek a better means of joining metal.

Oxy-Acetylene Welding

Acetylene gas was discovered in 1836, by Edmond Davey, an English chemist. It remained a laboratory gas until the development of a practical method of manufacturing calcium carbide nearly a half century later. Calcium carbide is the substance from which acetylene gas is now commercially generated.

The basis for the development of the oxy-acetylene welding process was the discovery by Le Chatelier, a French chemist, in 1895, that acetylene gas, when ignited and supported by oxygen, produced a flame 1000° F. hotter than any previously known flame. In a paper, read before the Academie des Sciences on the temperature of flames, Le Chatelier described the properties of the oxy-acetylene flame, calling attention to the two burning processes that take place before complete combustion is attained. As the two gases mix, the primary combustion of acetylene

with equal parts of oxygen results in the formation of hydrogen and carbon-monoxide, both of which are non-oxidizing in character. This primary combustion forms the outline of the inner cone of a neutral flame. The completed combustion takes place in the outer envelope of the flame, as these two gases combine with another one and one-half volumnes of oxygen from the atmosphere. A property of acetylene which he apparently did not discover, was the fact that as acetylene is made it absorbs a great deal of heat energy. This is in turn released in the form of heat energy as the combustion progresses. This endothermic property of acetylene accounts for the extremely high temperatures found in the oxy-acetylene flame.

The commercial method used in the manufacture of calcium carbide was perfected by Thomas L. Willson, the American electro-metallurgist, in 1891-92, as a result of a series of experiments with a misture of lime and coal tar heated to a high temperature in an electric furnace. The first factory established for the manufacture of carbide was in 1895, as a direct result of these experiments.

The application of the oxy-acetylene flame to the welding and cutting of steel dates experimentally to 1901, and industrially from 1903, although the growth and development was retarded because of the cost of obtaining oxygen in commercial quantities. During this time those industries attempting to use oxy-acetylene welding were limited by the amount of oxygen they could generate chemically. The development of an economical process for obtaining oxygen was almost entirely neglected until 1907, when a plant for the manufacture of liquid air was put into operation, providing the mill needed source of commercial oxygen for welding purposes.

The next problem to be dealt with was the design of a practical blowpipe or torch, designed to mix acetylene and oxygen in proper quantities for practical use. This was accomplished in 1901, when blowpipes of a practical design appeared on the market. The process was soon applied in manufacturing plants, for by 1903, many industries accepted oxy-acetylene welding as a repair tool.

The greatest limiting factor in the widening of the application of oxy-acetylene welding was the immobility of the equipment required to produce both the acetylene and the oxygen. This factor was partially overcome by the development of cylinders for transporting compressed oxygen. It was not practical to compress acetylene gas in cylinders due to the highly explosive characteristics of the gas. After much experimentation it was discovered that by packing a cylinder with porous material, such as infusional earth, and saturating this filler with liquid acetone, it would dissolve twenty-five times its own volumn of free acetylene, which could be compressed without danger to a pressure in excess of 250 lbs. per square inch. During the welding process the acetylene is given up by the mixture without appreciable loss of acetone from the container. This attainment in the handling of acetylene opened the way to rapid development of oxy-acetylene welding in industry.

Arc Welding

The early development of oxy-acetylene and arc welding took place at approximately the same time. Arc welding was first employed by De Meritens in 1881, in uniting pieces of lead plate which were to be used as part of a battery. He accomplished this by attaching a positive terminal to the lead plates and establishing an arc between a negative carbon electrode and the lead plates. The heat of the arc was used to

melt the plates together.

Following the application by De Meritens, the arc was used in welding steel and iron using a carbon arc with electrode negative. Later a bare metallic rod was substituted for the carbon electrode, and filler metal was transferred to the base metal through the medium of the arc. These welds proved to be superior to those made with carbon arc, because they retained their ductility and strength to a greater degree. One of the first uses made of this new metallic electrode was to fill holes in defective castings.

Resistance Welding

In 1886, Professor Eli Thompson was conducting an experiment with several batteries and quite by accident touched the terminals together. This caused an arc upon contact, and as resistance heated the wires, they fused together. This was the forerunner of the field of resistance welding, wherein the heat comes from the resistance to the passage of an electric current of the materials to be welded. In this process the metal is subjected to the flow of a high current until it is heated to a plastic state, when sufficient pressure is applied to force the heated metals together.

Modern resistance welds are of high quality and strength. They provide one of the most rapid means of fabrication and several metals can be successfully joined by this means that do not respond to other methods of welding.

Thermit Welding

In 1894, C. Vautin, discovered that by mixing powdered aluminum with iron-oxide, and subjecting the mixture to heat great enough to ignite it, that a reaction occurred that generated a temperature of

approximately 4880° F.

Dr. Hans Goldschmidt, a German scientist, proved by this experiment that aluminum has a greater affinity for oxygen than any other element. His greatest contribution was the discovery that the mixture made cold and ignited in a single spot without any additional heating would furnish sufficient heat to cause the reaction to spread throughout the complete mixture in approximately thirty seconds. He was issued a patent on this process on March 16, 1897.

It was nearly a year later that this reaction was used for welding. After the first attempts to weld with this process, it was adapted to use on a commercial scale very rapidly. This welding process became known as thermit welding taking its name from the science then known as aluminothermics, dealing with the reduction of metallic oxides to pure metal by the use of powdered aluminum as the reducing agent. The thermit welding process was introduced in America by the Goldschmidt Thermit Company in 1902, the company name was changed in 1918 to the Metal Thermit Corporation.

Atomic-Hydrogen Welding

In 1874 a type of electric blowpipe was proposed by Werdermann. This method consisted of using the flame gases of an electric arc deflected by a jet of air or gas. This idea was later revived by Zerener with the suggestion that the arc be deflected between the usual carbon electrodes by a magnetic field. These processes were the meager beginnings of a series of experiments using various combinations of the procedures just described.

Atomic-hydrogen-arc welding was developed as the result of these

experiments. Rossi describes this process as follows:[1]

> In the atomic-hydrogen arc welding process, an arc is maintained between two tungsten electrodes while a stream of hydrogen is passed through the arc around the electrodes. The stream, or flame, assumes a fan shape and produces a sharp singing noise.

Temperatures as high as 5342° F. have been calculated in the arc fan. This method of welding finds its greatest usefulness in the solution of special problems, such as welding alloys and thin sections which are not readily welded by other methods.

Heliarc Welding

In 1932, G. E. Doan conducted a series of experiments in which an arc was established between a carbon electrode and the base metal. The complete welding apparatus and the metal were enclosed in a case and argon gas was admitted to the enclosure by a system of valves so that the gas was changed every few seconds. The lack of a puddle caused some to believe it was a cumbersome and impractical method of welding, even though the deposited metal was exceptionally pure. Mr. Doan later working with W. C. Shultz substituted helium for the argon with greater success.

Since 1942, heliarc welding has undergone considerable development and improvement, with tremendous expansion in the usefulness and scope of the process.

H. T. Herbst gives this description of Heliarc welding.[2]

Heliarc welding is the new and different kind of electric

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[1] Quotation from Welding and Its Application, Boniface E. Rossi, page 60.

[2] H. T. Herbst, "Production Applications for Inert Gas-shielded Arc Welding," Welding Journal, 26:410, May, 1947.

arc welding that employes a sheath of inert gas to protect the virtually non-consumable tungsten electrode and weld puddle. It differs from atomic-hydrogen welding in that the arc is formed between the tungsten electrode and the work, instead of between two electrodes; and the protecting shield is inert and therefore non-reactive with the molten metal. This new type of welding with argon or helium is sometimes referred to as "inert gas-shielded arc welding".

Heliarc welding has been applied to many metals heretofore requiring a flux; however, nearly all metals that require a flux for any other type of welding do not require one when welded by the heliarc method. This welding process is now accepted as a standard method of weld fabricating.

Selected Bibliographies for Oxy-Acetylene and Electric Welding

This bibliography is divided into three sections. The first list includes textbooks that are usable for students of high school level. The second division lists textbooks suitable for college classes, and the last section lists technical reference books that should be in every welding shop library.

Textbooks Usable in High School

1. Air Reduction Sales Co., Arc Welding Instruction Course, Air Reduction Sales Co., New York, 1942, Two Books, Lectures 190 pages, Exercises 90 pages.
   A course in arc welding including numerous illustrations, color charts, and furnishes the instructor an excellent outline for instruction in the theory and practice of arc welding.

2. Air Reduction Sales Co., Oxy-Acetylene Welding and Cutting Instruction Course, Air Reduction Sales Co., New York, 1942, Two Books, Lectures 100 pages, Exercises 70 pages.
   These two books, available at no cost, present a very good source of information as textbooks or reference books. The fundamentals of oxy-acetylene welding and cutting are fully discussed.

3. Chaffee, W. J., Practical Arc Welding, Hobart Trade School Inc., Troy, Ohio, 1942, 412 pages.
This book contains an operators training course, general information, a glossary of welding terms, and covers the field of carbon arc and metallic arc welding thoroughly.

4. Dunwoody Industrial Training Institute, Gas Welding Job Training Units, American Technical Society, Chicago, 1942, 92 pages.
A combination textbook and workbook with replaceable work sheets available. It is well illustrated.

5. Giachino, J. W., Oxy-Acetylene Welding and Cutting, The Manual Arts Press, Peoria, Illinois, 1942, 196 pages.
Discusses oxy-acetylene equipment, welding processes for all positions, metal identification, welding steel, cast iron aluminum, brazing, airplane welding, and flame cutting.

6. Hubert, E. H., Manual of Electric Arc Welding, McGraw-Hill Book Co., Inc., New York, 1932, 163 pages.
An operator training course, contains a study of electric welding process, equipment, testing welds, joints, application, and speed of welding.

7. Jennings, R. F., General Shop, Gas and A.C. Welding and Cutting, McKnight and McKnight, Bloomington, Illinois, 1937, 84 pages.
A study of electric and oxy-acetylene welding equipment, techniques, welding of ferrous and non-ferrous metals, cutting, and a series of practice plates.

8. Kerwin, Harry, Arc and Acetylene Welding, McGraw-Hill Book Co. Inc., New York, 1944, 235 pages.
A study of oxy-acetylene and electric welding, equipment, techniques, expansion and contraction, hard facing, cutting, welding of ferrous and non-ferrous metals, metal identification, and a practice course.

9. Matteson, M. S., Oxy-Acetylene Welding, Bruce Publishing Co., Milwaukee, Wisconsin, 1942, 64 pages.
Contains information and exercises on the oxy-acetylene welding process, with questions for discussion. Written in language easily understood by the beginning high school student.

10. Matteson, M. S., Electric Welding, Bruce Publishing Co., Milwaukee, Wisconsin, 1942, 32 pages.
Twenty-four units in electric welding arranged in ascending order of difficulty. Each unit is organized in terms of equipment, information, and procedure.

11. Potter, Morgan H., Electric Welding, American Technical Society, Chicago, 1941, 77 pages.
A practical text covering the fundamental principles and applications of the various types of electric welding, including the use of power tube rectifiers.

12. Potter, Morgan H., Oxy-Acetylene Welding, American Technical Society, Chicago, 1941, 130 pages.
Discusses the oxy-acetylene welding processes, techniques welding of steel, cast iron, brass, aluminum, white metal, copper, brazing, flame cutting, pipe cutting, jigs, automobile repair, and the cost of welding.

13. Rice, William; Owens, Albert A. and Slinghuff, Ben F., Fundamentals of Electric Welding, John Weston Co., Chicago, 1943, 138 pages.
A technical textbook covering nearly all of the general phases of electric welding, glossary of terms, and a lesson series. It is well illustrated in all sections.

14. Rossi, Boniface E., Manual of Instructions in Welding and Cutting, McGraw-Hill Book Co. Inc., New York, 1941, 99 pages.
A series of instruction sheets in arc and oxy-acetylene welding, designed for teaching beginning students. Additional information on safety is included.

15. Wisconsin Schools of Vocational and Adult Education with Cooperation of Wisconsin State Board of Vocational Education and Adult Education, Student Study Guide in Arc and Gas Welding, American Technical Society, Chicago, 1947, 87 pages.
A study guide for on-the-job trainees and other learners.

Textbooks Suitable for College Classes

1. Moyer, James A., Welding, McGraw-Hill Book Co. Inc., New York, 1942, 184 pages.
Describes the various modern methods of welding metals, especially iron and steel, with stress upon gas heat and electric welding.

2. Plumley, Stuart, Oxy-Acetylene and Arc Welding, University Printing Press, Minneapolis, Minnesota, 1939, 402 pages.
Discusses oxy-acetylene equipment, welding of steel, aluminum, nickle, monel, copper, and various alloys, pipe welding, lead burning, and outlines laws, codes and rules of welding.

3. Rossi, Boniface E., Welding and Its Applications, McGraw-Hill Book Co. Inc., New York, 1941, 343 pages.
A clear, understandable treatment of the different welding processes, their related phenomena, techniques, and general applications in industry, with emphasis on the arc and oxy-acetylene processes.

4. Sacks, Raymond J., Theory and Practice of Welding, D. Van Nostrand Co. Inc., New York, 1944, 383 pages.
Discusses the industrial use of arc welding, equipment, electrodes, joints, welds and characteristics, testing of welds, flame cutting, safety in arc welding, welding symbols, and contains an operators training course.

Technical Reference Books for Welding

1. Air Reduction Sales Co., Manual of Design for Arc Welded Steel, Air Reduction Sales Co., New York, 1946, 381 pages.
A good reference dealing with design of structures fabricated from steel.

2. Althouse, Andrew D., and Trounquist, Carl H., Modern Welding Practice, The Goodheart-Wilcox Co. Inc., Chicago, 1942, 412 pages.
A study of the theory and practice of electric and oxy-acetylene welding of metals, both ferrous and non-ferrous; it includes discussions of welding equipment, weld testing, identification of metals, heat treatment of metals, pipe welding, and the welding shop.

3. American Welding Society, Welding Handbook, American Welding Society, New York, 1938, 1311 pages.
A handbook compiled from papers written by specialists in the welding field, covering the latest procedures and the latest information about research activities in the field of welding engineering.

4. Davies, A. C., The Science and Practice of Welding, Cambridge University Press, New York, 1941, 436 pages.
A discussion of oxy-acetylene and electric welding from the view point of the scientist.

5. The Industrial Publishing Co., Pocket Manual of Arc Welding, The Industrial Publishing Co., Cleveland, Ohio, 1943, 127 pages.
A study of electric welding, equipment, expansion and contraction, testing welds, welding metallurgy, electrodes, a glossary of terms, and symbols.

6. The Lincoln Electric Co., Procedure Handbook of Arc Welding Design and Practice, The Lincoln Electric Co., Cleveland, Ohio, 1945, 1282 pages.
A complete study covering all phases of arc welding.

7. Linde Air Products Co., The Oxy-Acetylene Handbook, The Linde Air Products Co., New York, 1943, 587 pages.
A study of the general principles of the oxy-acetylene process, welding of ferrous, and non-ferrous alloys, cutting, inspection and management.

8. Mackenzie, L. B., and Card H. S., The Welding Encyclopedia, The Welding Engineer Publishing Co., Chicago, 1943, 696 pages.
A study covering all phases of welding including electric, oxy-acetylene, thermit, resistance, and atomic-hydrogen welding.

9. Oxweld Acetylene Co., The Oxwelders Manual, Oxweld Acetylene Co., Chicago, 1929, 228 pages.
A study of oxy-acetylene welding history, welding and cutting processes, welding of ferrous and non-ferrous metals, and safety practices.

10. Sykes, F. W., Drawing and Development for Practical Welding, Pitman Publishing Co., Chicago, 1944, 72 pages.
A study of drawing and sketching as applied to welding and includes weld joints, their use, simple developments for welded construction, distortion problems, and how they may be overcome.

11. Frankland, Thomas W., Pipe Fitters' and Pipe Welders' Handbook, The Bruce Publishing Co., Milwaukee, 1945, 160 pages.
A pocket-sized reference manual for pipe fitters and pipe welders, containing the clearly presented, amply illustrated, and simply arranged information needed by tradesmen in the field.

Periodicals on Welding

1. Flashes, The Thomson-Gibb Electric Welding Co., Lynn, Massachusetts, Free.
A monthly publication on production welding by the use of resistance welders.

2. Grits and Grinds, Norton Co., Worchester, Massachusetts, Free.
A monthly publication on grinding methods and grinding wheels.

3. Hobart Arc Welding News, Hobart Brothers Co., Box AN-42, Troy, Ohio, Free. This magazine or arc welding news is a compilation of articles submitted by the users of Hobart equipment, and the readers of the Hobart Arc Welding News.

4. Industry and Welding, Industrial Publishing Co., 1240 Ontario, Cleveland, Ohio, Free.
A monthly periodical covering the latest practices in welding repair, maintenance, fabrication, and lists welding equipment supply companies and manufacturers. Contains an advertisers equipment index.

5. Oxy-Acetylene Tips, Linde Air Products Co., New York, Free.
A monthly magazine which covers the latest methods of oxwelding as applied to the various industries.

6. The P & H Weld, Harnschfeger Corporation, 4400 West National, Milwaukee, Wisconsin, Free.
Published every other month and contains articles on metallurgy, repair, production and maintenance.

7. The Stabilizer, The Lincoln Electric Company, Coit Road and Kirby Ave., Cleveland, Ohio, Free.
Published every two months. Contains descriptions of many unusual repair and production jobs. A good magazine for instructor, student and welding operator.

8. The Welding Engineer, The Welding Engineer Publishing Co., McGraw-Hill Book Co. Inc., 330 W. 42nd St., New York, Price $5.00 per year.

A monthly issue publishing current articles on welding techniques, cutting, brazing, flame treating, design, construction, and also covers the very latest procedures in production, inspection, maintenance and salvage.

9. Weld-It, The Taylor-Winfield Corporation, Warren, Ohio, Free. A monthly pamphlet concerning resistance welding news about applications of spot, projection, seam, and flash-butt welding machines and equipment.

10. The Welding Journal, The American Welding Society, Publication Office, 20th and Northampton Streets, Easton, Pennsylvania. Price $5.00 per year. A monthly issue covering current welding problems, and new developments in welding. Published for the advancement of the science and art of welding.

Free or Nearly Free Teaching Aids for Welding

Welding is a comparatively new trade or science and for that reason all manufacturers of welding equipment want to make their products known. In so doing, they publish an abundance of material that is of considerable value to the welding instructor as well as to the operator. Much of this material has never been included in any textbook on welding and yet every welding student should know that this material is available so that he may obtain it and make it a part of his working knowledge.

All of the larger welding equipment companies have a publicity department where they cause to be printed from time to time the latest information on recent developments in their fields. It is possible for any welding instructor to have his name placed on the company mailing list without cost. In this way the teacher may benefit from the experiments carried on in the finest welding laboratories in the world. The following is a list of valuable teaching aids:

1. Color Guide to Airco Electrodes, Air Reduction Sales Co., New York. A sheet listing several Airco electrodes indicating their color markings as a means of identifying them and listing the recommended use for each.

2. Common Faults in Arc Welding, Hobart Brothers Co., Troy, Ohio.

An excellent booklet on the faults of many welders and suggestions on how to overcome them.

3. Destructive and Non-Destructive Tests, The Linde Air Products Co., New York. A critical discussion of the methods of testing welds including; tensile, fatigue, hardness, hydrostatic, stethoscopic, x-ray, electrical resistance and magnetic testing.

4. Fabrication of Oxy-Acetylene and Welded Steel and Wrought Iron Piping, The Linde Air Products Co., New York.
A very good booklet on pipe welding, templet layout and installation of welded piping.

5. Handbook for the Welding and Cutting Operator, International Acetylene Association, New York. This booklet contains many valuable suggestions on welding and cutting.

6. Oxwelding for General Maintenance, The Linde Air Products Co., New York. This booklet tells of the widespread utility of the oxy-acetylene welding process in all kinds of maintenance. It contains many short cut methods.

7. Precautions and Safe Practices, The Linde Air Products Co., New York. A twenty-four page booklet on the do's and don'ts of oxy-acetylene welding. A very excellent source of information on safety practices.

8. Preventing Welding and Cutting Fires, International Acetylene Association, New York. A booklet full of good suggestions for the prevention of welding and cutting fires in the shop.

9. Randall Tip Cleaner Data Sheet, Welding Cutting Materials Co., 1852 Burlington Ave., North Kansas City, Missouri. A sheet listing all popular brands of oxy-acetylene welding and cutting torches with the size designation of the company and the number of the drill size corresponding to it for every welding tip and cutting tip.

10. Stoody Handbook for Hard-Facing Farm Equipment, Stoody Co., Whittier, California. A booklet discussing the standard practices used in hard-facing all kinds of farm machinery and hand tools used on the farm.

11. Welding Procedures, Air Reduction Sales Co., New York, Price, sixty cents. An excellent booklet discussing the choice of welding rod, welding process, and the proper procedure for many types of jobs.

All of these materials are free with the exception of the last booklet, Welding Procedures, which is sixty cents. Most companies are

glad to send copies of their literature to instructors and students upon request. This is an excellent method of learning about the latest welding developments. The writer suggests that a file of such current material be kept in the high school library. Discussions of this material should be included as a regular phase of instruction whenever it is practicable to do so.

An Equipment List for a High School Welding Course

Oxy-acetylene and arc welding may be offered either as two separate courses, or more commonly as a combination course including the fundamentals of both. In the choice of welding equipment for a high school shop it is strongly recommended that nationally known brands of equipment be purchased from local distributors who have an established service department. Thus, if equipment is broken, or in need of repair, the delay necessary to put it back into operation is kept at a minimum.

This equipment list is in three parts, (1) Oxy-acetylene welding equipment, (2) Electric welding equipment, (3) and auxiliary equipment needed in a welding shop.

Oxy-Acetylene Welding Equipment

5	Combination welding outfits, each consisting of the following items: Welding torch, cutting attachment, 5 tips, sizes 2, 4, 5, 8, and 10, 2-stage acetylene regulator, 2-stage oxygen regulator, 25' of 1/4" twin welding hose, welding goggles with #5 lens, sparklighter, wrench and tip cleaners.	$ 609.00
1	Preheating furnace with table (shop fabricated).	15.00
5pr.	Blacksmith tongs - 14"	7.50
5	Welding tables, 18"x30"x36" high (shop made)	50.00
5	Welding stools (shop made)	10.00
1	Acetylene generator portable - 30 lbs. cap..	142.00
	Total.	$ 833.50

Electric Welding Equipment

3	Welding machines DC 200 amperel complete with standard accessory packs containing the following: 1-35' length #2 cable, 1-30' length #2 cable, electrode holder, 1 ground clamp, 2 lug terminal attachments, helmet with #10 lens and cover lens, wire brush, and leather gloves.	$ 918.00
2	Welding machines AC 300 amperel complete with accessory packs containing the following: 1-35' length #1/0 cable, 1-30' length of #1/0 cable, electrode holder, ground clamp, helmet with #10 lens and cover lens, wire brush, and leather gloves	600.00
5	Hand shields	8.60
5pr.	Welding gloves	13.50
5	Chipping hammers (shop fabricated)	1.00
5	Welding booths (shop made from plywood or sheet metal) .	150.00
1	Exhaust blower	75.00
5	Welding stools (shop fabricated)	10.00
1	Spot welder, KVA 10 - 18" Cap Throat, 16 Gauge cap . . .	425.00
	Total.	$ 2201.10

Auxiliary Equipment Needed in the Welding Shop

2	Anvils - 100 lbs	30.00
5	Cold chisels - 3/8" to 1".	2.50
1	Drill, portable electric 1/2" cap.	50.00
1	Drill press, floor model with motor.	
1set	Drills, twist, 3/64" to 1/2" by 64 Ths, high speed . . .	16.50
6	Files, mill bastard, with handles 8" to 12".	2.10
3	Files, round - 8" to 12"	.90
2	Files, half round - 8" to 12".	.60
1	Grinder, bench type, heavy duty - 10".	90.00
1	Grinder, pedistal heavy duty - 12"	154.00
3	Punches, center - 3/16" to 3/8".	1.75
4	Hacksaw frames, hand adjustable - 12".	5.25
2	Combination square sets including center head and bevel protractor.	8.00
2	Machinist vises - 6" jaws.	22.50
1	Grinding wheel dresser	1.20
10pr.	Safety goggles	15.00
2	Hammers, engineers - 2 lbs	2.80
2	Hammers, ball pien - 16 oz	1.80
6	Screwdrivers common - 6" to 12".	3.60
2	Wrenches, pipe - 18" and 24"	8.00
2	Carpenter squares - 24".	6.00
10	Pocket tapes - 6'.	15.00
1	Work bench - 36"x72"-36" high (shop built)	24.00
1	Bench shear - 12 guage capacity.	30.00
1	Power hack saw	50.00
	Total.	$ 551.47

Summary of the Cost of Welding Shop Equipment

Total cost of Oxy-acetylene Welding Equipment.	$ 833.50
Total cost of Electric Welding Equipment	2201.10
Total cost of Auxiliary Equipment.	551.47
Total.	$ 3586.07

This equipment list was made up as a near ideal supply of tools. Schools first installing a welding shop should get only a portion of these tools and build up their inventory as the expansion of the program makes the need apparent.

A List of Oklahoma Supply Companies Furnishing Welding Equipment

The companies whose names are included in the following list sell both oxy-acetylene and arc welding equipment, machines, and supplies. Several of them maintain service departments for all makes of equipment and also have branch offices in the smaller towns of the state.

1. Air Reduction Sales Co., 1521 South Agnew, Oklahoma City, and 305 East First, Tulsa.
2. Allis-Chalmers Mfg. Co., 901 West Grand, Oklahoma City.
3. Big Three Welding Equipment Co., 2750 Sand Springs Road, Tulsa, and 1643 Exchange, Oklahoma City.
4. Harris Calorific Oxy-Acetylene Welding Equipment, 113 South Denver, Tulsa.
5. Hart Industrial Supply Co., 308 East Fourth, Tulsa, and 411 West California, Oklahoma City.
6. Hobart Welding Equipment Co., 214 East Third, Tulsa.
7. Hobart Welder Sales and Service, 518 South Robinson, Oklahoma City.
8. Independent Supply Co., 1406 North Eastern, Oklahoma City.
9. Kraut Welding Equipment Co., 2813 N.W. 16th, Oklahoma City.
10. Lincoln Electric Co., 25 East California, Oklahoma City, and 2750 Sand Springs Road, Tulsa.
11. Linde Air Products Co., 1700 South Agnew, Oklahoma City, and 524 Exchange National Bank Bldg. and 320 S. Boston, Tulsa.

12. Marshall Supply and Equipment Co., 109 West First, Tulsa.

13. Mideke Supply Co., 100 East Main, Oklahoma City.

14. National Cylinder Gas Co., 2131 N.E. 10th, Oklahoma City, and 311 East Third, Tulsa.

15. Sooner Oxygen and Supply Co., 517 S. Robinson, Oklahoma City.

16. Welder's Supply, Sales and Service, 422 S. Walker, Oklahoma City.

A Recommended Course of Study for Oxy-Acetylene and Electric Welding

The following outline for a course of study in welding includes units for the theory of welding as well as the laboratory exercises. It does not purport to be either complete or rigid in its requirements, but is written as an aid to the instructor in formulating his own course of study. This guide includes both oxy-acetylene and electric welding outlines and covers enough material to be used as a two-year course in welding.

Recommended Textbooks for High School Welding

There are several very good textbooks in the field of welding. Those listed in this paragraph were chosen because in the opinion of the writer they fit the need for a basic textbook in a high school course in welding. Every student should be supplied with a textbook. The student must learn virtually a new vocabulary of technical terms in connection with the course, and in addition, a set of procedures and techniques peculiar to welding field.

1. Giachino, J. W., Oxy-Acetylene Welding and Cutting, The Manual Arts Press, Peoria, Illinois, 1942, 196 pages.

2. Kerwin, Harry, Arc and Acetylene Welding, McGraw-Hill Book Co., New York, 1944, 235 pages.

3. Matteson, M. S., Oxy-Acetylene Welding, Bruce Publishing Co., Milwaukee, 1942, 64 pages.

4. Rossi, Boniface E., Manual of Instructions in Welding and Cutting, McGraw-Hill Book Co., New York, 1941, 99 pages.

The Course of Study Outline

Each unit of study is documented in the three textbooks listed below. The number preceding the name of the textbook corresponds to its column on the right hand side of the page.

1. Matteson, M. S., Oxy-Acetylene Welding.
2. Rossi, Boniface,E., A Manual of Instructions in Welding and Cutting.
3. Kerwin, Harry, Arc and Acetylene Welding.

A Course of Study in Oxy-Acetylene Welding

Theory Units		1	2	3
Unit 1.	Modern applications of welding			
2.	Oxy-acetylene welding	9	67	1
3.	Safety Practices in the oxy-acetylene welding shop	64	67	133
4.	Oxy-acetylene welding equipment and its care	13	71	4
5.	Oxy-acetylene cutting equipment and its care	43	98	14
6.	The acetylene generator	30		5
7.	Acetylene gas, its manufacture, containers and storage	10	71	6
8.	Oxygen, its manufacture and storage	10	72	4
9.	Weldability of metals			
10.	Definition of welding terms			
11.	Preheating, its effect and use	34	91	114
12.	Pipe welding and templet layout	58	85	80

Laboratory Exercises for Oxy-Acetylene Welding		1	2	3
Unit 1.	Setting up the oxy-acetylene welding equipment	13	71	17
2.	Lighting adjusting and shutting off the torch	16	74	22
3.	Carry a puddle on black iron sheet 14 to 16 gauge	17	76	29
4.	Cutting with a cutting torch	43	98	14,16
5.	Deposit a straight bead with a filler rod	17	76	26
6.	Weld a closed corner weld on black iron sheet (without filler rod)		77	30
7.	Weld a butt joint flat position		79	31
8.	Weld a butt joint vertical position	30	82	52
9.	Weld a lap joint flat position		81	42
10.	Weld a butt joint horizontal	32	86	39
11.	Weld a lap joint vertical		83	44
12.	Weld a tee joint flat	23	81	45
13.	Weld a tee joint vertical		82	48
14.	Weld a butt joint overhead		84	
15.	Weld a lap joint overhead		84	
16.	Weld a tee joint overhead		84	
17.	Weld a single vee butt joint flat on caste iron	39	91	114
18.	Braze a single vee butt joint flat on caste iron	46	92	126
19.	Rolling weld butt joint on 2" to 4" pipe	58		57

Laboratory Exercises (continued)		1	2	3
Unit 20.	Weld a flat flanged joint in aluminum 14 gauge sheet	49	94	
21.	Butt weld caste aluminum flat			

A Course of Study in Electric Welding

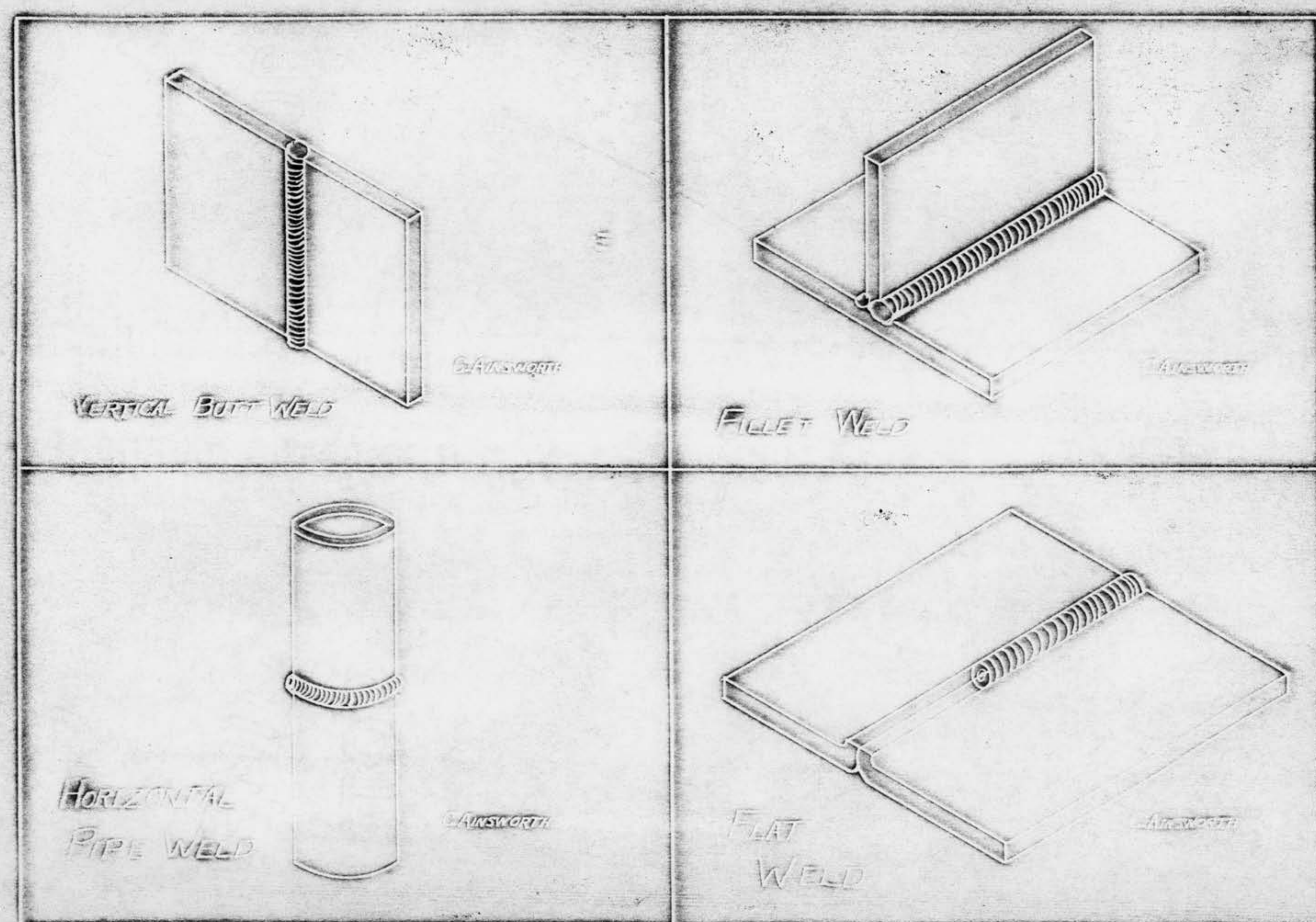
Theory Units				
Unit 1.	Industrial applications of arc welding			
2.	Types of electric welding machines			137
3.	Safety practice in arc welding		1	146
4.	Care of electric welding equipment		1	137
5.	Setting the current for electric welding			139
6.	The electrode and its arc		4,5	144
7.	Testing welded specimens			229
8.	Expansion, contraction, and residual stresses		14	109
9.	Welding jigs and fixtures			

Laboratory Exercises in Electric Welding				
Unit 1.	Setting up the electric welding equipment			137
2.	Striking and holding the arc		3	150
3.	Running parallel beads with bare electrodes flat		3	150
4.	Running parallel beads with coated electrodes		5	152

Laboratory Exercises (continued)		1	2	3
Unit	5. Build up a pad		13	155
	6. Weld a tee joint flat		10	156
	7. Run parallel beads vertical		39	187
	8. Weld a tee joint vertical		19	164
	9. Weld a butt joint flat		10,32	180
	10. Weld a butt joint vertical		20,44	187
	11. Run parallel beads horizontal		39	
	12. Weld a butt joint horizontal		22,47	194
	13. Run parallel beads overhead		23,48	190
	14. Weld a tee joint overhead		51	
	15. Weld a butt joint overhead		52	190
	16. Weld a butt joint in caste iron flat with nickle rod			214
	17. Electric braze a butt joint in caste iron (may be eliminated if desired)			126
	18. Butt weld aluminum flat			220

The Use of Projects in Welding Courses

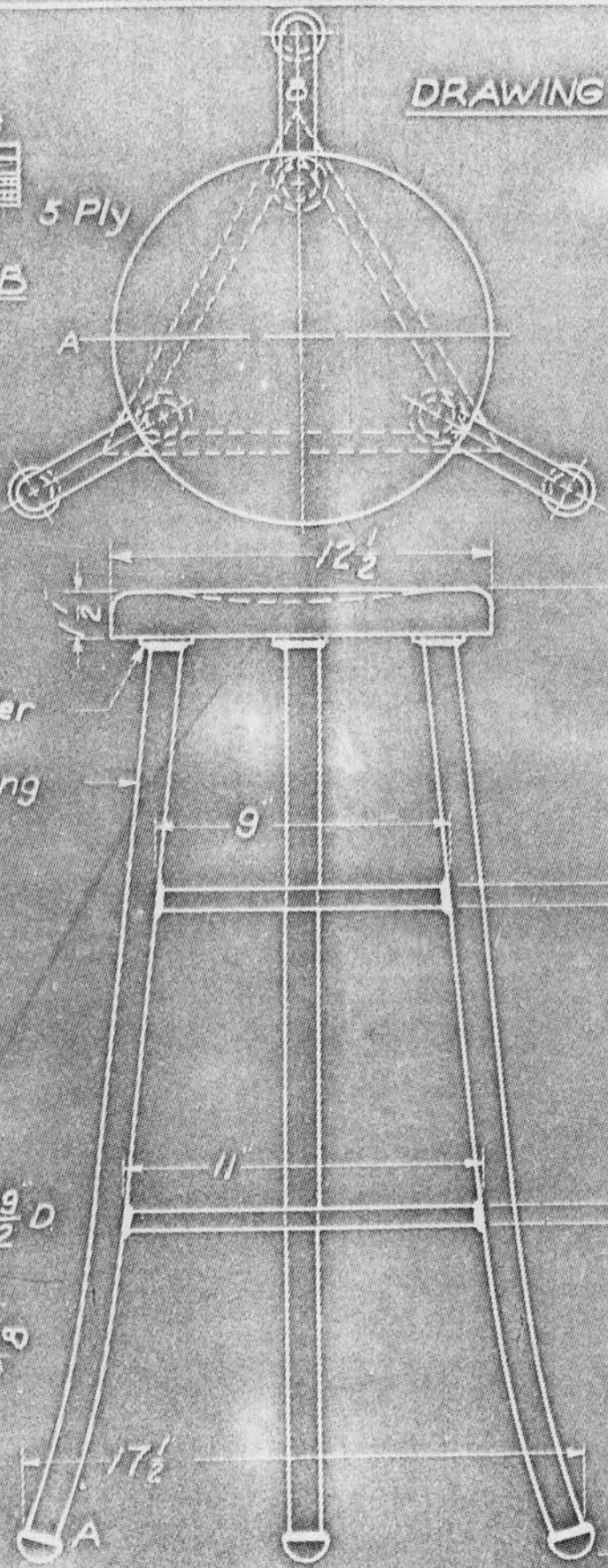
The following drawings are of exercises and projects to be used in the course. The exercises were picked at random and are to be used where the instructor feels they are most needed. It is not recommended that the projects be used until the latter part of the course because most students will not be ready to make welds that will give satisfactory service until that time.


VERTICAL BUTT WELD
C. AINSWORTH
FILLET WELD
C. AINSWORTH
HORIZONTAL
PIPE WELD
C. AINSWORTH
FLAT
WELD
C. AINSWORTH

DRAWING STOOL

5 Ply

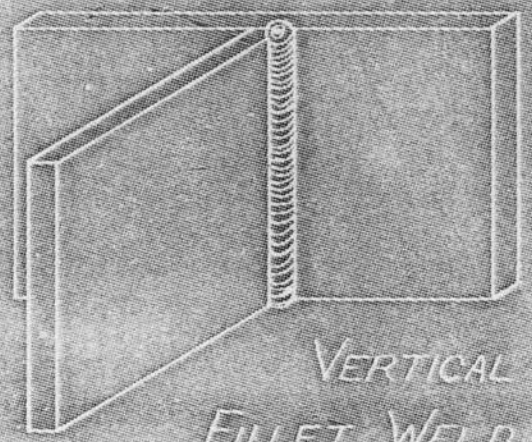
SECTION A-B



DETAIL A

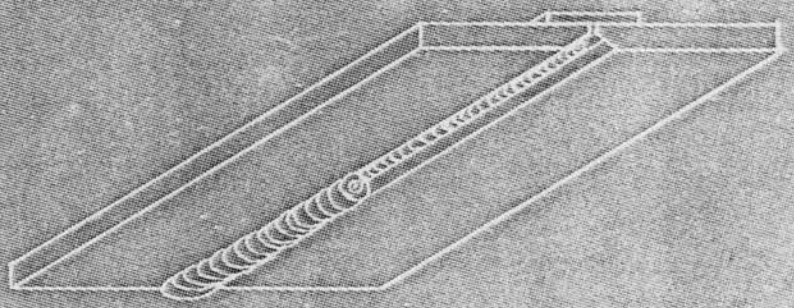
B. KORN	SECOND ANNUAL OKLAHOMA STATE INDUSTRIAL ARTS CLINIC	SCALE: 3/16 = 1"

C. AINSWORTH



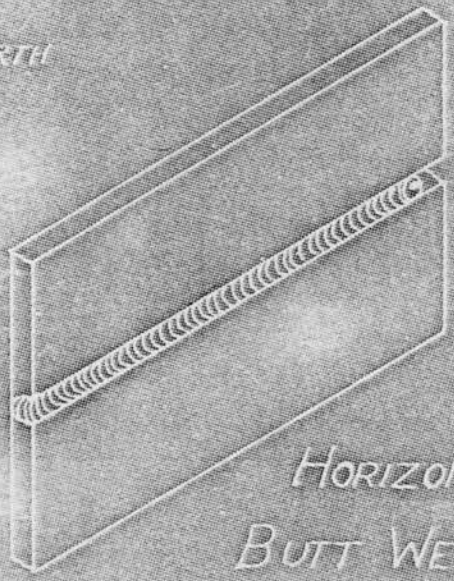
VERTICAL
FILLET WELD

C. AINSWORTH



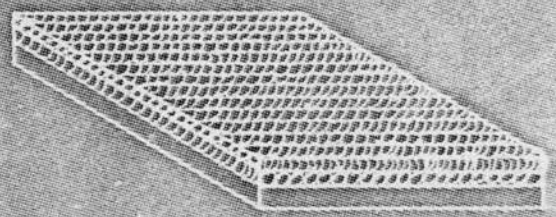
OVERHEAD WELD

C. AINSWORTH

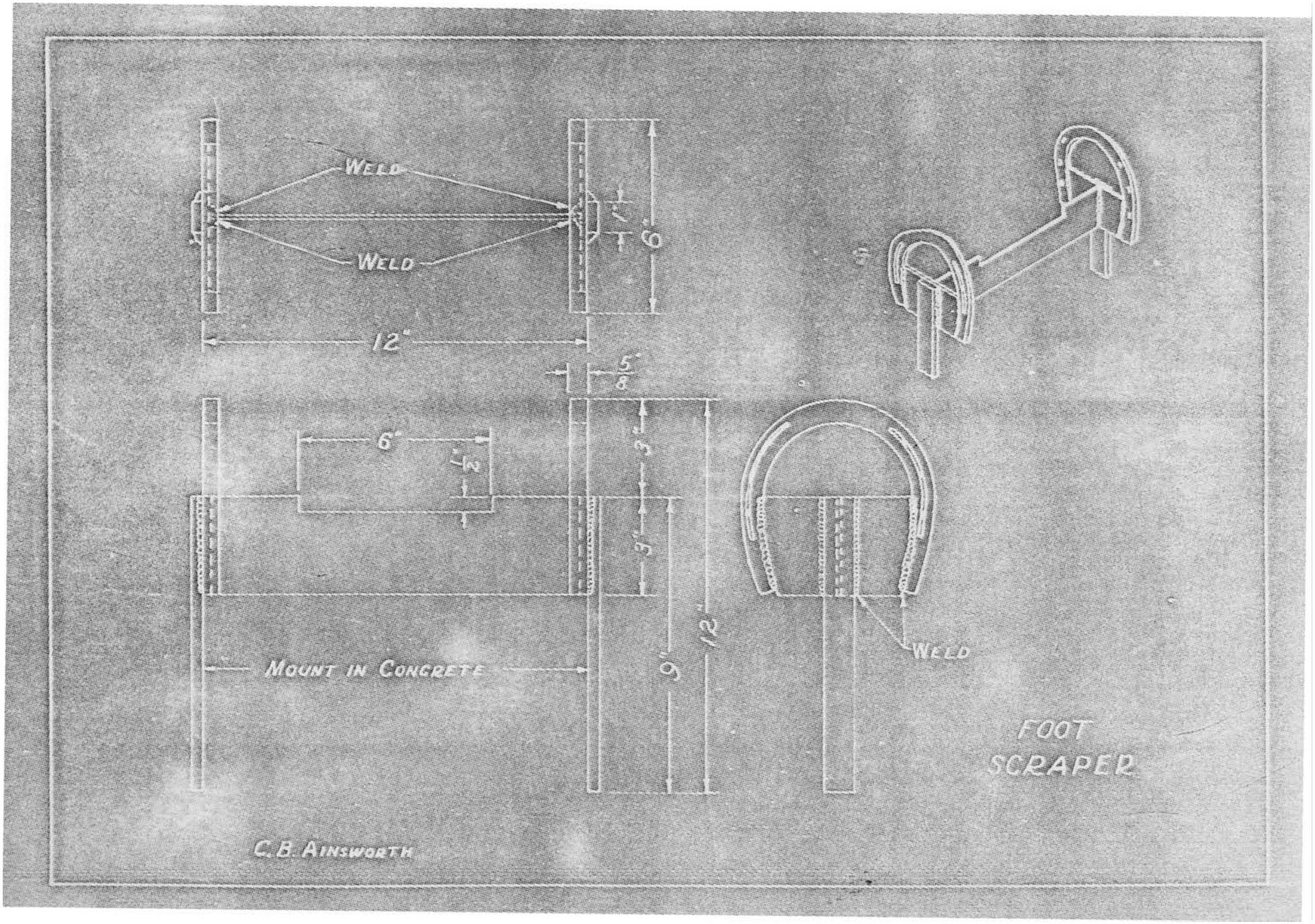


HORIZONTAL
BUTT WELD

C. AINSWORTH



BUILD A PAD


WELD
WELD
6"
12"
5/8
6"
1/2
3"
3"
9"
12"
MOUNT IN CONCRETE
WELD
FOOT SCRAPER
C. B. AINSWORTH

Suggested Test Questions for a Course in Welding

The following test questions are divided into two sections, the first for electric welding, the second for oxy-acetylene welding. Both sections contain true-false test statements, multiple choice questions, recall questions, and completion questions. They are questions of a general nature the answers to which would be found in any standard welding textbook.

True-False Test Questions for Electric Welding

Study the statement carefully. If the statement is true, place a "T" in the space preceding the number of the question; if it is false, place an "F" in the space provided. Example:

F 1. Skin will not sunburn from the electric arc.

____ 1. The term "getting a flash" is the result of watching an arc without any protection for the eyes.

____ 2. A left handed man can usually weld better if the electrode is held in the right hand.

____ 3. There are two accepted ways of striking an arc with an electric welder.

____ 4. Striking an arc with a scratching motion is not a standard procedure.

____ 5. If the sound of an arc is a steady crackling sound, it indicates that a good arc is being held by the operator.

____ 6. After an arc has been established, it should be held at the starting point long enough for the fusion to start before moving on.

____ 7. Running a bead too fast results in an uneven bead.

____ 8. Advancing too slowly tends to burn the base metal excessively.

____ 9. A short arc is recommended for bare electrodes.

____ 10. The ideal fillet weld is the shape of a triangle.

____ 11. In making a fillet weld on a T joint, a long arc tends to reduce undercutting.

____ 12. In making a butt joint a slight weaving motion helps to get a better penitration.

____ 13. A short arc is essential for a successful vertical weld.

____ 14. A long arc is an aid in depositing a uniform overhead bead.

_____15. It is unnecessary to remove the slag when using bare electrode.

_____16. The residue left on the top of the weld with coated electrode should be removed before the weld turns black.

_____17. Choking the arc means to hold it as close to the base metal of the crater for an instant, and then pulling it away quickly.

_____18. At the change of electrodes, no special procedure is needed to cover the depression left by the crater.

_____19. The weaving pattern does not need to be uniform.

_____20. A carbon electrode is used to establish polarity on a DC welding machine.

_____21. When welding thin plates together, no allowance need be made for expansion and contraction.

_____22. When steel is heated it expands, and when it cools it contracts.

_____23. In carbon arc welding no filler rod can be used.

_____24. Arc welding can readily be adapted to automatic welding.

_____25. Welding electrodes which are made for reverse polarity, welding on a DC welder, may be used on an AC welder if desired.

Multiple Choice Test Questions for Arc Welding

Directions to student: Underscore the correct answer to the following questions and place the number of your choice in the parenthesis at the right of each question. See example.

Example: Beads should be deposited from (1) left to right (2) right to left (3) either direction..... (1)

1. The proper clothing to wear during arc welding is (1) a pair of goggles, (2) adequate covering over exposed skin, (3) ordinary clothing..... ( )

2. After striking the arc, the electrode should be (1) advanced down the weld immediately (2) pulled away as far as possible to hold the arc (3) held momentarily to start fusion..... ( )

3. The electrode should be held at an angle of about (1) 45° (2) 20° (3) 30° to the work being welded..... ( )

4. Too slow movement causes (1) poor fusion (2) an uneven bead (3) excessive burning..... ( )

5. Too fast movement in running a bead results in (1) an uneven bead (2) good fusion (3) excessive burning..... ( )

6. In case your eyes get "flash" burned from the arc, the best relief is to (1) rub your eyes vigorously (2) apply butyn sulfate solution (3) lay down and close your eyes..... ( )

7. Arc blow is (1) a wind blowing the arc stream (2) a magnetic condition causing an unstable arc (3) the result of too high of a current setting..... ( )

8. Arc blow is more evident on (1) AC welders (2) DC welders (3) is the same on both..... ( )

9. The temperature of the arc stream is (1) 5500° F. (2) 6500° F. (3) 7500° F..... ( )

10. Beads should be deposited from (1) left to right only (2) right to left only (3) either direction..... ( )

11. A crater is (1) a tool (2) a slag inclusion (3) the end of a weld..... ( )

12. When an arc is unsteady and blows excessively the cause is (1) too high a setting on the machine (2) wrong polarity (3) the ground is poor..... ( )

13. A good arc can be identified by (1) a steady splatter, (2) a steady cracking sound (3) a long puddle..... ( )

14. When a multiple pass weld is used (1) only one bead is needed (2) only a filler bead is needed (3) at least a stringer bead and a finish bead are needed..... ( )

15. Assuming 1/4" metal is used, which joint requires the least preparation? (1) butt (2) lap (3) double vee butt joint..... ( )

16. In the shielded arc welding process the electrode (1) has no coating (2) has a heavy coating (3) may or may not be coated... ( )

17. A transformer welder is a (1) DC welder (2) AC welder (3) either an AC or DC welder..... ( )

18. A crater appears where the (1) weld starts (2) weld ends (3) slag fails to float out of the weld..... ( )

19. Choking the arc refers to (1) starting a weld (2) stopping the arc (3) breaking the arc..... ( )

20. Polarity on a DC machine may be determined by using a (1) heavily coated electrode (2) a carbon electrode (3) a tungsten electrode..... ( )

Completion Test Questions for Arc Welding

This is a completion test. Fill in the proper word in the blank space in each of the following questions. One word is all that is necessary unless more than one space is provided. Study the example carefully and then start the test.
Example: The term used to refer to electric welding is arc welding.

1. AC is the abbreviation for _____ _____.
2. DC is the abbreviation for _____ _____.
3. The name for the weld used on a lap joint is a _____ weld.
4. The four position welds are (1)_____(2)_____ (3)_____(4)_____.
5. _____ is the name applied to an electric current that reverses its direction of flow at regular intervals.
6. An _____ is the state of an electrical current jumping across a gaseous gap that is a part of the circuit.
7. There are two general types of tests used in testing welds. They are _____ and _____.
8. _____ _____ is the action of the arc where it is unstable and jumps in various directions due to a magnetic condition.
9. The _____ is the depression at the termination of the weld.
10. The method used to build up a round shaft where each bead is deposited at an angle of 180 degrees from each other is called _____ welding.

Oxy-Acetylene Welding True-False Test

Study the statement carefully. If the statement is true, place a "T" in the space preceding the number of the question; if it is false, place a "F" in the space provided.

_____ 1. Acetylene is a colorless, odorless gas that will burn.

_____ 2. Early progress in oxy-acetylene welding was slow due to the difficulty in producing oxygen in commercial quantities.

_____ 3. A 3% acetylene and 97% air mixture is explosive.

_____ 4. An early use of oxygen was as a gas for home lighting.

_____ 5. Acetylene gas is almost wholly free of carbon-monoxide gas.

_____ 6. Calcium carbide is produced by melting lime and coke together in an electric furnace.

_____ 7. The core of an acetylene gas cylinder is filled with charcoal, asbestos, corn pith, etc. and is saturated with acetone.

_____ 8. Oxygen gas will not burn but supports combustion.

_____ 9. One volume of liquid acetone at normal temperature and pressure will absorb twenty-five times its own volume of acetylene.

_____10. The oxy-acetylene torch supplies approximately equal parts of oxygen and acetylene.

_____11. The temperature of an oxy-acetylene neutral flame is approximately 5800° F.

_____12. An oxidizing flame is hotter than a neutral flame.

_____13. When setting up welding equipment, the hose and the torch should be blown out with gas pressure before they are connected for use.

_____14. It is considered good practice to cut down the flow of gas in a given size tip, so that less heat is obtained from the flame for welding.

_____15. Oxides and impurities can be floated out of a weld by mixing the molten puddle.

_____16. Expansion of the metal to be welded can be ignored in material of 1/8 inch thickness or less.

_____17. The purpose of rotary motion of the torch in welding is to secure good penitration.

_____18. Clean metal is harder to weld than dirty rusty material.

_____19. A wash weld is a weld that is used to cover up poor workmanship.

_____20. An acetylene generator should contain one gallon of water for each pound of acetylene.

_____21. No source of heat should be allowed in the acetylene generator room.

_____22. The size of opening in the tip may be drilled larger if desired.

_____23. All hose connections should be strictly leak proof.

_____24. It is permissible to use an acetylene cylinder when it is laying down.

_____25. Caste iron contains 3 to 4% carbon and about 94% iron.

_____26. Material as similar as possible to the base metal should be used as filler rod.

_____27. V blocks, shims, surface plates, and clamps may be used to secure proper alignment when welding.

_____28. There are three standard types of pressure regulators.

_____29. A good welder is usually a slow welder.

_____30. There is never an occasion when welding equipment should be lubricated with grease.

Multiple Choice Test Questions for Oxy-Acetylene Welding

Directions to students: Underscore the correct answer to the following questions and also write the number of the correct response in the parenthesis at the right of each question.
Example: Gas welding is a (1) pressure fusing (2) semi-pressure (3) non-pressure, process..... (3)

1. The melting point of mild steel is (1) 2300° F. (2) 2700° F. (3) 2500° F..... ( )

2. A welding flame with an excess of oxygen is a (1) neutral (2) oxidizing (3) a carburizing, flame..... ( )

3. A welding flame with an excess of acetylene is (1) an oxidizing (2) a neutral (3) a carburizing, flame..... ( )

4. The oxy-acetylene welding torch should be held so that the flame hits the work at a (1) 20 (2) 45 (3) 90 degree angle..... ( )

5. The acetylene hose connection can be identified by (1) red hose and standard threads (2) black hose and left hand threads (3) red hose and left hand threads..... ( )

6. Free acetylene gas can be compressed to (1) 250 lbs (2) 15 lbs (3) 30 lbs per square inch without danger..... ( )

7. An ingot is (1) a tool (2) a piece of unprocessed metal (3) a special welding instrument..... ( )

8. Aluminum can be welded by (1) arc welding only (2) all common types of welding (3) oxy-acetylene welding only..... ( )

9. The hottest type of flame is the (1) oxidizing (2) neutral (3) carburizing..... ( )

10. Annealing is a heating process designed to (1) soften metal (2) harden metal (3) make metal lighter..... ( )

11. A fully charged cylinder of oxygen contains (1) 2500 (2) 250 (3) 2000 to 2500 lbs per square inch..... ( )

12. There is danger of an excess of acetone being given off it more than (1) 1/4th (2) 1/10th (3) 1/7th, of the total volume is drawn off in one hour..... ( )

13. Soaking when used in terms of heat treating means to (1) put steel in hot water over night (2) to subject steel to high temperature for stress relieving for an extended period of time (3) to keep metal wet for extended periods of time..... ( )

14. If an excess of oxygen is used when welding steel, it causes (1) the puddle to boil and adds carbon (2) the metal to be burned away (3) a good weld to be made..... ( )

15. When the gas welding torch hisses, it indicates that there is an excess of (1) carbon (2) acetylene (3) oxygen in the mixture..... ( )

16. The space from which the metal has been removed by a cutting process is called a (1) joint (2) layer (3) kerf..... ( )

17. A size 23 tip should be cleaned with a size (1) 23 (2) 33 (3) 13 tip drill..... ( )

18. Portable equipment for generating (1) oxygen (2) acetylene (3) hydrogen, are used frequently in welding shops..... ( )

19. Welding is the process of fusing two (1) similar (2) dissimilar (3) non-ferrous metals together..... ( )

20. Scale forms on hot metal as the result of a combination of (1) nitrogen (2) carbon dioxide (3) oxygen, and the hot metal.. ( )

21. Thermit welding uses as a source of heat for the weld (1) a chemical reaction (2) a forge fire (3) a welding flame..... ( )

22. Thermit welding produces a (1) very brittle weld (2) impure weld (3) a very good weld..... ( )

23. Thermit welding is especially applicable to (1) small sections (2) large sections (3) medium sections of metal..... ( )

24. Before cutting with the oxy-acetylene cutting torch, steel must be preheated to (1) 800 to 1000° F. (2) 1400 to 1600° F. (3) 2500 to 2700° F..... ( )

25. Machine cutting is accurate to (1) 1/8" (2).100" (3) .003"..... ( )

Completion Test Questions for Oxy-Acetylene

This is a completion test. Insert the proper word in the blank space in each of the following questions. One word is all that is necessary unless more than one space is provided.

1. The substance used to cleanse metals and desolve oxides when welding is called a _____.

2. There are two general types of regulators used in oxy-acetylene welding, they are _____ _____ and _____ _____.

3. _____ welding is the term applied to welding when the flame is directed on the completed weld rather than on the unwelded metal.

4. _____ is an alloy consisting of copper and tin.

5. _____ is the term used when referring to the shrinkage of a weld on cooling from the molten state.

6. The material that is added to a weld which has been Veed out is called _____ _____.

7. The three parts of a carburizing flame are the _____ _____, the _____, and the _____ _____.

8. The instrument used to ignite acetylene gas when it is turned on is called a _____.

9. When setting up oxy-acetylene welding equipment, the practice of partially opening the cylinder valves before attaching the welding regulator is called _____ the valve.

10. The type of flame used for case hardening is a _____ flame.

It is suggested by the writer that frequent short tests be given throughout the course as a check on the progress of the student. These tests should be of two general types, written and performance. These will also serve as a measure of the success of the instructor as well as an aid in the discussion of the more important points covered in both the study of information units and the laboratory exercises. Selections from the various types of test questions furnishes a reliable measure of the student's knowledge of welding.

Summary, Conclusions and Recommendations

With the ever widening application of welding it is evident that the installation of a welding shop in the high school is justified, whether it is located in a farming community or an industrial center. Welding machines are finding their way into every working man's world, whether it is on the farm, the factory or elsewhere. Every high school capable of supporting an Industrial Arts Department should have a welding shop to strengthen this program.

After a careful study of this paper and the suggested material, it is reasonable to assume that the value of a course in welding for high school, whether they are terminal students or future college students, cannot be overlooked. It gives the terminal student a salable skill upon which to build. It gives the future farmer an indispensable repair tool.

Efficiency and safety in the use of oxy-acetylene and electric welding processes must even precede careful observance of correct operating procedures. Welding and cutting are not particularly hazardous, but common-sense precautions must be taken and enforced. The dangers of burn and electric shock are inherent in this course, and students must be continually warned about possible dangers. Safety practice cannot be stressed too thoroughly or too often.

It is recommended that only the mature type of student be allowed to enroll in welding, preferably those classified as juniors or seniors. The lack of seriousness or purpose in the less mature student makes them undesirable as welding pupils.

The writer recommends that a two-hour class period every day of the

school week is necessary to cover the material in the recommended course of study outline in one school year. If less time is allotted, the course should be of two years duration.

The initial investment necessary for the installation of a welding shop appears at first to be quite high; however, with very little maintenance and care, this equipment will last for many years. Replacement costs of this high priced equipment are low if spread over its total use. The return per dollar invested compares satisfactorily with any other shop operated in the Industrial Arts program.

With the growth of welding has come a great demand for welding operators of every type which require a continuous training program. It is sincerely hoped that this paper might be an aid to instructors who are attempting to supply this demand.

Typed by:

Velma Jean Peters