Title: History of Welding

Objectives

Students will be able to read an article and sequence a series of events.

Time frame to Complete

30-45 minutes

NRS EFL

4

Stackable Cert. Documentation	Technology	Study / Life skills	EL-Civics	Career Pathways	Police	Paramedic	Fire Rescue	Medical Asst.	EKG / Cardio	Phlebotomy	Practical Nursing	Healthcare Admin	Pharmacy Tech	IMT	AMT	HVAC	Welding	Other:						
																	X							

Standard(s) Addressed in Lesson

Read for Understanding

Benchmark(s) Addressed in Lesson

R.4.8. Understand meaning of some specialized content vocabulary (for example, "constitution").
R.4.11. Apply, monitor and adjust comprehension strategies (for example, note subtle details in texts, pose questions about text) to understand text at an inferential level.
R.4.12. Use structural elements and organizational strategies (for example, problem and solution, cause and effect) to aid in comprehension of print and electronic texts.
R.4.15. Draw conclusions about text using knowledge of main idea(s) and supporting details, consistent with complexity of the text.

Materials

History of Welding article available from http://www.rodovens.com/welding_articles/history.htm
Sequencing activity – pre-cut into strips
Answer key

Learner Prior Knowledge

Students should understand chronological order.

Activities

Step 1 Establish purpose for the activity. Understanding sequences can help people better understand the events as well as cause and effect relationships, thereby making one's knowledge more complete. When reading, there are often cues to help us organize information in a logical sequence. Often, there are dates; words such as *first, next, meanwhile, later*; or phrases such as *in the beginning*, *as a result*, or *in conclusion*.

Step 2 Distribute the *History of Welding* article. Students will read the passage to learn about significant inventions and developments in the history of welding. They should also pay attention to the sequencing cues in the passage. Encourage them to circle any sequencing cues they notice.

Step 3 After students read the article, discuss sequencing cues they found. (For example: specific dates are used; the article is organized in sections by date; words such as *first, meanwhile, soon, recent, until, today, ancient, earliest, nineteenth century* are used in the article to provide information about the order of events.)

Step 4 Students complete the sequencing activity based upon the passage. Students receive a series of events from the *History of Welding* reading passage (pre-cut into strips). Students put the events in chronological order. They may reread the passage as needed.

Step 5 Once students have put the events in order, they should check their work using the answer key. If there were errors in their sequence, they should reread the passage or consult with the teacher in order to understand the proper order of events.

Assessment/Evidence

Completed sequencing activity

Adaptations for Beginning Students

Beginning students may work with a partner.

Adaptations for Advanced Students

Advanced students may choose one type of welding mentioned in the *History of Welding* article (i.e. forge, arc, stud, GTAW, laser) and complete independent research to create a timeline of significant discoveries, inventions, and events related to that type of welding.

Teacher Reflection/Lesson Evaluation

This lesson was created by Middletown ABLE.

History of Welding

Middle Ages
Welding can trace its historic development back to ancient times. The earliest examples come from the Bronze Age. Small gold circular boxes were made by pressure welding lap joints together. It is estimated that these boxes were made more than 2000 years ago. During the Iron Age the Egyptians and people in the eastern Mediterranean area learned to weld pieces of iron together. Many tools were found which were made approximately 1000 B.C.
During the Middle Ages, the art of blacksmithing was developed and many items of iron were produced which were welded by hammering. It was not until the 19th century that welding, as we know it today was invented.

1800
Edmund Davy of England is credited with the discovery of acetylene in 1836. The production of an arc between two carbon electrodes using a battery is credited to Sir Humphry Davy in 1800. In the mid-nineteenth century, the electric generator was invented and arc lighting became popular. During the late 1800s, gas welding and cutting was developed. Arc welding with the carbon arc and metal arc was developed and resistance welding became a practical joining process.

1880
Auguste De Meritens, working in the Cabot Laboratory in France, used the heat of an arc for joining lead plates for storage batteries in the year 1881. It was his pupil, a Russian, Nikolai N. Benardos, working in the French laboratory, who was granted a patent for welding. He, with a fellow Russian, Stanislaus Olszewski, secured a British patent in 1885 and an American patent in 1887. The patents show an early electrode holder. This was the beginning of carbon arc welding. Bernardos' efforts were restricted to carbon arc welding, although he was able to weld iron as well as lead. Carbon arc welding became popular during the late 1890s and early 1900s.

1890
In 1890, C.L. Coffin of Detroit was awarded the first U.S. patent for an arc welding process using a metal electrode. This was the first record of the metal melted from the electrode carried across the arc to deposit filler metal in the joint to make a weld. About the same time, N.G. Slavianoff, a Russian, presented the same idea of transferring metal across an arc, but to cast metal in a mold.

1900
Approximately 1900, Strohmenger introduced a coated metal electrode in Great Britain. There was a thin coating of clay or lime, but it provided a more stable arc. Oscar Kjellberg of Sweden invented a covered or coated electrode during the period of 1907 to 1914. Stick electrodes were produced by dipping short lengths of bare iron wire in thick mixtures of carbonates and silicates, and allowing the coating to dry. Meanwhile, resistance welding processes were developed, including spot welding, seam welding, projection welding and flash butt welding. Elihu Thompson originated resistance welding. His patents were dated 1885-1900. In 1903, a German named Goldschmidt invented thermite welding that was first used to weld railroad rails. Gas welding and cutting were perfected during this period as well. The production of oxygen and later the liquefying of air, along with the introduction of a blow pipe or torch in 1887, helped the development of both welding and cutting. Before 1900, hydrogen and coal gas were used with oxygen. However, in about 1900 a torch suitable for use with low-pressure acetylene was developed. World War I brought a tremendous demand for armament production and welding was pressed into service. Many companies sprang up in America and in Europe to manufacture welding machines and electrodes to meet the requirements.

1919
Immediately after the war in 1919, twenty members of the Wartime Welding Committee of the Emergency Fleet Corporation under the leadership of Comfort Avery Adams, founded the American Welding Society as a nonprofit organization dedicated to the advancement of welding and allied processes. Alternating current was invented in 1919 by C.J. Holslag; however it did not become popular until the 1930s when the heavy-coated electrode found widespread use.

1920
In 1920, automatic welding was introduced. It utilized bare electrode wire operated on direct current and utilized arc voltage as the basis of regulating the feed rate. Automatic welding was invented by P.O. Nobel of the General Electric Company. It was used to build up worn motor shafts and worn crane wheels. It was also used by the automobile industry to produce rear axle housings. During the 1920s, various types of welding electrodes were developed. There was considerable controversy during the 1920s about the advantage of the heavy-coated rods versus light-coated rods. The heavy-coated electrodes, which were made by extruding, were developed by Langstroth and Wunder of the A.O. Smith Company and were used by that company in 1927. In 1929, Lincoln Electric Company produced extruded electrode rods that were sold to the public. By 1930, covered electrodes were widely used. Welding codes appeared which required higher-quality weld metal, which increased the use of covered electrodes. During the 1920s there was considerable research in shielding the arc and weld area by externally applied gases. The atmosphere of oxygen and

nitrogen in contact with the molten weld metal caused brittle and sometime porous welds. Research work was done utilizing gas shielding techniques. Alexander and Langmuir did work in chambers using hydrogen as a welding atmosphere. They utilized two electrodes starting with carbon electrodes but later changing to tungsten electrodes. The hydrogen was changed to atomic hydrogen in the arc. It was then blown out of the arc forming an intensely hot flame of atomic hydrogen during to the molecular form and liberating heat. This arc produced half again as much heat as an oxyacetylene flame. This became the atomic hydrogen welding process. Atomic hydrogen never became popular but was used during the 1930s and 1940s for special applications of welding and later on for welding of tool steels.

H.M. Hobart and P.K. Devers were doing similar work but using atmospheres of argon and helium. In their patents applied for in 1926, arc welding utilizing gas supplied around the arc was a forerunner of the gas tungsten arc welding process. They also showed welding with a concentric nozzle and with the electrode being fed as a wire through the nozzle. This was the forerunner of the gas metal arc welding process. These processes were developed much later.

1930

Stud welding was developed in 1930 at the New York Navy Yard, specifically for attaching wood decking over a metal surface. Stud welding became popular in the shipbuilding and construction industries. The automatic process that became popular was the submerged arc welding process. This "under powder" or smothered arc welding process was developed by the National Tube Company for a pipe mill at McKeesport, Pennsylvania. It was designed to make the longitudinal seams in the pipe. The process was patented by Robinoff in 1930 and was later sold to Linde Air Products Company, where it was renamed Unionmelt® welding. Submerged arc welding was used during the defense buildup in 1938 in shipyards and in ordnance factories. It is one of the most productive welding processes and remains popular today.

1940

Gas tungsten arc welding (GTAW) had its beginnings from an idea by C.L. Coffin to weld in a nonoxidizing gas atmosphere, which he patented in 1890. The concept was further refined in the late 1920s by H.M.Hobart, who used helium for shielding, and P.K. Devers, who used argon. This process was ideal for welding magnesium and also for welding stainless and aluminum. It was perfected in 1941, patented by Meredith, and named Heliarc® welding. It was later licensed to Linde Air Products, where the watercooled torch was developed. The gas tungsten arc welding process has become one of the most important. The gas shielded metal arc welding (GMAW) process was successfully developed at Battelle Memorial Institute in 1948 under the sponsorship of the Air Reduction Company. This development utilized the gas shielded arc similar to the gas tungsten arc, but replaced the tungsten electrode with a continuously fed electrode wire. One of the basic changes that made the process more usable was the small-diameter electrode wires and the constant-voltage poser source. This principle had been patented earlier by H.E. Kennedy. The initial introduction of GMAW was for welding nonferrous metals. The high deposition rate led users to try the process on steel. The cost of inert gas was relatively high and the cost savings were not immediately available.

1950

In 1953, Lyubavskii and Novoshilov announced the use of welding with consumable electrodes in an atmosphere of CO2 gas. The CO2 welding process immediately gained favor since it utilized equipment developed for inert gas metal arc welding, but could now be used for economically welding steels. The CO2 arc is a hot arc and the larger electrode wires required fairly high currents. The process became widely used with the introduction of smaller-diameter electrode wires and refined power supplies. This development was the short-circuit arc variation which was known as Micro-wire®, short-arc, and dip transfer welding, all of which appeared late in 1958 and early in 1959. This variation allowed all-position welding on thin materials and soon became the most popular of the gas metal arc welding process variations.

1960

Another variation was the use of inert gas with small amounts of oxygen that provided the spray-type arc transfer. It became popular in the early 1960s. A recent variation is the use of pulsed current. The current is switched from a high to a low value at a rate of once or twice the line frequency. Soon after the introduction of CO2 welding, a variation utilizing a special electrode wire was developed. This wire, described as an inside-outside electrode, was tubular in cross section with the fluxing agents on the inside. The process was called Dualshield®, which indicated that external shielding gas was utilized, as well as the gas produced by the flux in the core of the wire, for arc shielding. This process, invented by Bernard, was announced in 1954, but was patented in 1957, when the National Cylinder Gas Company reintroduced it.

In 1959, an inside-outside electrode was produced which did not require external gas shielding. The absence of shielding gas gave the process popularity for noncritical work. This process was named Innershield®. The electroslag welding process was announced by the Soviets at the Brussels World Fair in Belgium in 1958. It had been used in the Soviet Union since 1951, but was based on work done in the United States by R.K. Hopkins, who was granted patents in 1940. The Hopkins process was never used to a very great degree for joining. The process was perfected and equipment was developed at the Paton Institute Laboratory in Kiev, Ukraine, and also at the Welding Research Laboratory in Bratislava, Czechoslovakia. The first production use

in the U.S. was at the Electromotive Division of General Motors Corporation in Chicago, where it was called the Electro-molding process. It was announced in December 1959 for the fabrication of welded diesel engine blocks. The process and its variation, using a consumable guide tube, is used for welding thicker materials. The Arcos Corporation introduced another vertical welding method, called Electrogas, in 1961. It utilized equipment developed for electroslag welding, but employed a flux-cored electrode wire and an externally supplied gas shield. It is an open arc process since a slag bath is not involved. A newer development uses self-shielding electrode wires and a variation uses solid wire but with gas shielding. These methods allow the welding of thinner materials than can be welded with the electroslag process. Gage invented plasma arc welding in 1957. This process uses a constricted arc or an arc through an orifice, which creates an arc plasma that has a higher temperature than the tungsten arc. It is also used for metal spraying and for cutting. The electron beam welding process, which uses a focused beam of electrons as a heat source in a vacuum chamber, was developed in France. J.A. Stohr of the French Atomic Energy Commission mad the first public disclosure of the process on November 23, 1957. In the United States, the automotive and aircraft engine industries are the major users of electron beam welding.

Most Recent

Friction welding, which uses rotational speed and upset pressure to provide friction heat, was developed in the Soviet Union. It is a specialized process and has applications only where a sufficient volume of similar parts is to be welded because of the initial expense for equipment and tooling. This process is called inertia welding. Laser welding is one of the newest processes. The laser was originally developed at the Bell Telephone Laboratories as a communications device. Because of the tremendous concentration of energy in a small space, it proved to be a powerful heat source. It has been used for cutting metals and nonmetals. Continuous pulse equipment is available. The laser is finding welding applications in automotive metalworking operations.

Put these 10 events in chronological order.

Auguste De Meritens (of France) used the heat of an arc for joining lead plates for storage batteries. This was the beginning of carbon arc welding.

The electroslag welding process was introduced at the Brussels World Fair.

Oscar Kjellberg (of Sweden) invented a covered (or coated) electrode.

Blacksmithing was developed and items were produced which were welded by hammering.

Laser welding is used for cutting metals and nonmetals. One of its important uses is in automotive metalworking operations.

Stud welding was developed at the New York Navy Yard, specifically for attaching wood decking over a metal surface.

C.J. Holslag invented the alternating current in 1919.

Heliarc® welding was patented.

Gage invented plasma arc welding in 1957.

Automatic welding was invented by P.O. Nobel of the General Electric Company. It was used to build up worn motor shafts and worn crane wheels. It was also used by the automobile industry to produce rear axle housings.

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