MERIT BADGE SERIES

INVENTING

Scouting America

How to Use This Pamphlet

The secret to successfully earning a merit badge is for you to use both the pamphlet and the suggestions of your counselor.

Your counselor can be as important to you as a coach is to an athlete. Use all of the resources your counselor can make available to you. This may be the best chance you will have to learn about this particular subject. Make it count.

If you or your counselor feels that any information in this pamphlet is incorrect, please let us know. Please state your source of information.

Merit badge pamphlets are reprinted annually and requirements updated regularly. Your suggestions for improvement are welcome.

Who Pays for This Pamphlet?

This merit badge pamphlet is one in a series of more than 100 covering all kinds of hobby and career subjects. It is made available for you to buy as a service of the national and local councils of Scouting America. The costs of the development, writing, and editing of the merit badge pamphlets are paid for by Scouting America in order to bring you the best book at a reasonable price.

Send comments along with a brief statement about yourself to
Program Development Department
Scouting America • 1325 West Walnut Hill Lane • Irving, TX 75038 If you prefer, you may send your comments to merit.badge@scouting.org

SCOUTING AMERICA
MERIT BADGE SERIES

INVENTING

LEMELSON-MIT

The Inventing merit badge and pamphlet were made possible in part by the Lemelson–MIT Program.

"Enhancing our youths' competitive edge through merit badges"

Scouting America

Note to the Counselor

While the scope of inventing projects is far too wide to cover here, there are some general guidelines and concerns that a merit badge counselor should keep in mind. Be mindful of managing risk and using good judgment when undertaking any invention project. Remember, an injury that doesn't happen needs no treatment; an emergency that doesn't occur requires no response.

See the *Composite Materials, Home Repairs, Woodwork, Emergency Preparedness,* and *First Aid* merit badge pamphlets for more information about safety, first aid, and managing risk.

Safety is the top priority, so Scouts who are working on their inventions should follow safety precautions whenever using tools, equipment, and other materials. In a workshop setting, use the buddy system. Be sure Scouts know they should always work under the supervision of a responsible adult who is knowledgeable about the tools, equipment, and materials they plan to use.

Working on inventions can take place in home workshops, in school shops, or even in community shops. When working outside of the home, be sure to familiarize Scouts with the safety requirements of the shop. Some shops require a basic safety class or will have minimum age requirements to use equipment like a lathe or milling machine.

Here are some basic rules to follow:

- Use the proper personal protective equipment, including body, hand, ear (such as protective foam ear plugs), and eye-face protection (such as safety glasses with side shields), closed-toe shoes, and foot coverings.
- Use protective clothing whenever necessary to prevent exposure to hands, eyes, and face, and to keep hazardous materials from contaminating street clothes.

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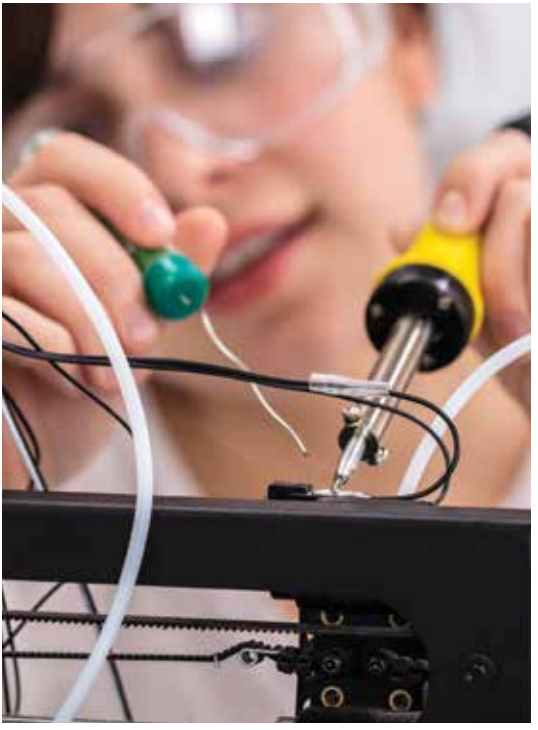
- Be trained on any equipment you plan to use *before* you get started.
- If fine particles in the air are anticipated—even in a well-ventilated area—be sure to have the proper respiratory equipment on hand for protection from dust, exhaust, and fumes.
- Never tolerate horseplay when using tools.
- Stay an arm's length away from others using tools or equipment.
- Know where the "off" switch is before turning on a power tool.
- Clean up the area every time work is finished and return all tools to their proper location.
- Have a first-aid kit and fire extinguisher on hand.
- *Ask questions;* never assume or guess!



Wear close-fitting clothing. Loose or baggy clothing can easily get caught in machinery.


Transition®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Requirements

Scouts should go to scouting.org/merit-badges/inventing or check Scoutbook for the latest requirements.

Scan this QR code for the latest Inventing requirements.

Contents

What Is Inventing?

Inventing is the process of finding *technological solutions* to real-world problems.

Italicized terms such as *inventing, engineering, entrepreneurship,* and *innovation* can be found in the glossary toward the end of this pamphlet.

The Spirit of Inventing

The spirit of inventing involves a combination of experimentation, investigation, inquisitiveness, and creative thinking. Inventing is an exciting journey of discovery, often yielding mixed or unexpected results along the way. In a sense, inventing is described by the phrase "thinking outside the box."

By learning about inventors and the way they think, you will begin to understand the importance of developing skills and approaches to thinking that are essential for the process of inventing. You have probably heard of McCormick, Ford, and the Wright Brothers, but what about Leatherman, Ball, Dietrich, or Amarasiriwardena? They are all modern or contemporary inventors. As you work toward your Inventing merit badge, you will discover that it is never too early to begin your own journey toward inventing.

Inventors are **curious** about the world around them.

Inventing Defined

To invent is to create something new that is useful or helpful, by means of your own investigation, experimentation, and thinking.

Inventiveness is a form of creative problem-solving, resulting in an invention.

An invention is the product of the inventing process. Inventions can be manufactured products, machines or electrical devices, chemical compounds and drugs, varieties of plants, methods of doing something, designs for useful objects, or improvements to any of these.

How is inventing different from *routine problem-solving?* Inventing crosses the boundaries of the way things have been done in the past. It ties together academic disciplines in unexpected ways, redefines the problem itself, or challenges long-held beliefs about the limits of what is possible. Inventive thinking challenges what we expect or anticipate.

The Segway® Personal Transporter was invented by Dean Kamen, the $500,000 Lemelson-MIT Prize winner in 2002 and founder of FIRST Robotics.

A few groundbreaking inventions, known as *seminal* inventions, have created entirely new industries or totally changed the nature of an existing industry. For example, in 1942 the common way to make a copy of a letter was to place carbon paper between two sheets of plain paper, reproducing on the bottom sheet whatever was written or typed on the top sheet. To make multiple copies, people used wet, smelly "spirit duplicators" ("spirit" refers to the alcohol solvents used in these machines), or they photographed the letter and had prints made, or they used expensive typesetting and a printing press. In that year, a physicist named Chester Carlson received patent number 2,297,691 for a machine to make copies on plain paper using static electricity and powder. Carlson's invention—which he named "xerography" (a term that means "dry writing")—led to plain-paper copiers in every office. Haloid, the company to which he licensed the patent, changed its name to Xerox®. Since then, all of the patents issued for inventions in the field of plain-paper printing—including the laser printer—are *improvement patents* upon Carlson's basic system.

Plain-paper photocopying is an example of a seminal or original invention.

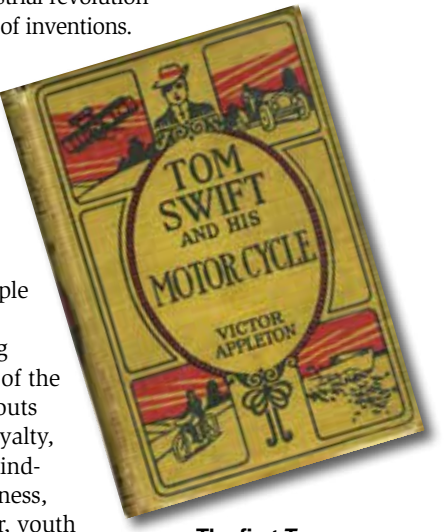
Invention vs. Innovation

Innovation is not the same as invention, although sometimes the two terms are used interchangeably. In its basic sense, *invention* is the creation of a product or the introduction of a process for the first time. *Innovation* is improving on or making a significant contribution to developing a product, process, or service. Society benefits from an invention after innovation proceeds to develop and introduce the new idea into use. *Inventing, engineering,* and *entrepreneurship* are all part of innovation.

History of Inventing

By nature and necessity, human beings are inventive. The wheel, compass, paper, paved roads, matches, and many other important discoveries date from antiquity. Within the last 500 years, the scientific revolution (1520–1750) and the first industrial revolution (1760–1850) laid the foundation for an outpouring of inventions.

The second industrial revolution, which began in the late 1860s, after the Civil War, brought about a period of accelerated inventive activity into the early 1900s. This led to dramatic changes in our society as we transitioned from an agriculturally based market to a manufacturing-oriented economy. Our economic system is now knowledge-centered. Along the way, inventions have improved living conditions for countless people around the world.



The first *Tom Swift* book was published in 1910.

Scouting America's involvement in inventing goes back to the early 20th century at the height of the second industrial revolution. In 1910, the Boy Scouts of America was founded to "cultivate courage, loyalty, patriotism, brotherliness, self-control, courtesy, kindness to animals, usefulness, cheerfulness, cleanliness, thrift, purity, and honor" in boys. That same year, youth were introduced to the fictional inventor Tom Swift. A series of books about Tom portrayed him as a natural inventor with an American entrepreneurial spirit. By testing, tinkering, building, and experimenting, Tom created his own inventions, including an airship, photo telephone, and a Taser-like device he called an electric rifle.

Like Tom Swift, many Scouts were experimenting with inventions of their own as they worked toward the Invention merit badge. As the 1911 *Boy Scouts of America Handbook for Boys* states, "To obtain a merit badge for Invention a Scout must: 1) Invent and patent some useful article; and 2) Show a

working drawing or model of the same." With such stringent requirements, only 10 Invention merit badges were ever earned, and the badge was discontinued in 1915. But the ideas of invention and innovation—finding new solutions to problems, understanding new technologies, learning new skills, and thinking in new ways—were prevalent in other Scouting activities and throughout America during the decade of 1910–1920.

In 1913, Henry Ford adopted the assembly line manufacturing process, revolutionizing the automobile industry. By 1915, the millionth Model T had rolled off the assembly line. At an average cost of about $500 each, cars became affordable for the first time for many American families. The widespread availability of cars created the need for a range of innovations: new road systems, laws, service stations, and repair shops. Scouts were earning the Automobiling merit badge, which required them to obtain their driver's license, and understand the functions of various automobile parts, including the clutch, carburetor, and spark plugs.

In 1911, electricity was changing American family life. Through early 20th century innovations, electricity was becoming more accessible to Americans, especially in urban areas. Electricity in homes meant consistent and reliable lighting, heating, and eventually, appliances like toasters and electric ovens. In 1911, Scouts could earn an Electricity merit badge by making an electromagnet, repairing broken electric connections, and knowing how to resuscitate someone who received an electric shock.

The Invention merit badge, circa 1911

The Automobiling merit badge, circa 1911

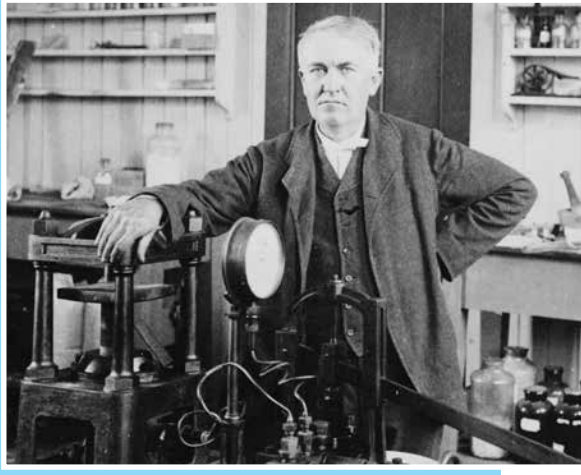
Thomas A. Edison, American Inventor

The inventor Thomas Alva Edison (1847–1931) helped to shape the modern world with such inventions as the incandescent light bulb, the phonograph, and the motion picture camera. He also made improvements to the telegraph and telephone. In his lifetime, he acquired 1,093 patents. He was also a successful manufacturer and entrepreneur who marketed his inventions to the public.

Edison's laboratory in Menlo Park, New Jersey, was an "invention factory" that produced a nearly constant stream of inventions and improvements. In 1877, he invented a phonograph by which sound could be recorded on a tinfoil-coated cylinder. Within two years came his long-lasting incandescent electric light bulb, which was perhaps his most important contribution. In 1882, in New York City, he installed the world's first commercial electrical lighting system.

In 1888, Edison and his associate, William K.L. Dickson, invented the kinetoscope, a type of motion picture camera. By synchronizing his phonograph and kinetoscope, Edison's laboratory produced the first talking motion pictures in 1913.

His other significant inventions included an alkaline storage battery, the mimeograph machine (an inexpensive printing press that forced ink through a stencil onto paper), and a wireless telegraphic method for communicating with moving trains.



Thomas Edison was among the most productive inventors in history.

Inventions today, just like 100 years ago, help make life healthier, more comfortable, more informed, more engaging, and more productive.

Scouts and Radio

The German physicist Heinrich Hertz made possible the development of radio, television, and radar by proving that electricity can be transmitted wirelessly in electromagnetic waves. In 1887 he became the first to broadcast and receive radio waves.

Hertz did not recognize the full importance of his experiments. Others, however, better understood how to put his discoveries to practical use. The Italian electrical engineer Guglielmo Marconi is generally credited as the inventor of radio. In 1896, Marconi transmitted radio signals for more than a mile, and applied for his first British patent. By 1902, messages were regularly radioed across the Atlantic Ocean, and by 1905 many ships were using radio to communicate with shore stations.

The first Boy Scout handbook (1911) included complete instructions for making "an up-to-date wireless apparatus for stationary use in the home or at the meeting place of each patrol."

In the early years of this new technology, many Scouts built their own radios and experimented with simple receivers called *crystal sets*. The name came from the receiver's most important component, a crystal detector originally made with a lump of mineral such as galena, a form of lead ore. The user could move a fine wire called a "cat's whisker" along the flat surface of a galena crystal to find a spot where the surface formed a natural semiconductor. At that point, the crystal set would start receiving radio signals. Sold and homemade by the millions, the inexpensive crystal radio played a major role in introducing radio to the public.

During the 1920s, radio blossomed, bringing music, news, and new ideas into American homes. Other technologies also developed: Airplanes, movies, and refrigerators changed

the ways Americans lived. The nation changed, and so did Scouting America, introducing merit badges to help youth explore and master new technologies, and to help them become "efficient leader[s] in the paths of civilization and peace."

The Aviation merit badge, circa 1911

While we don't know the names of the 10 Scouts who earned the first Invention merit badges, nor do we know what they invented, we do know that they were living in a technologically exciting time. Today is just as exciting. We are not inventing airplanes just to fly in the air or automobiles just to drive on roads, but rather we are inventing airplanes that can be both flown and driven. Inventors are developing ways to target tumor cells with gold *nanoparticles* to treat cancer, with fewer side effects. Cell phones are being used to collect health care data so the quality of life can be improved in developing countries like Kenya.

What will Scouts who earn the Inventing merit badge invent?

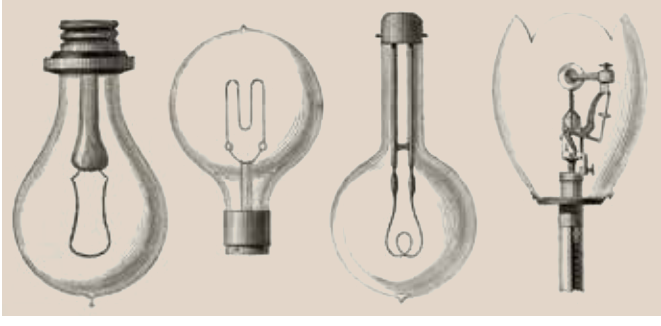
The Transition roadable aircraft is a plane that can fold its wings and be driven along the road like a car.

Impact of Inventing on Humankind

The impact of inventing on humankind is inestimable. Not only have inventions improved the quality of life for countless people around the world, they have also changed the course of history and the foundations of modern society. Technology has become such a large part of our daily lives that we cannot imagine surviving without the conveniences it has brought to us. Imagine living without your cell phone. Texting would not exist, and to make phone calls you would have to use a landline.

The changes our society has experienced in moving from an agriculturally based market to a manufacturing-oriented economy and now to a knowledge-centered economic system have created fertile ground for Scouts to devise ingenious solutions to a wide range of problems to help humankind. There are countless opportunities for new products and services that take advantage of high-speed worldwide communications and transportation. We live in an exciting time with a global environment for knowledge sharing and distance learning, both of which foster opportunities for working together to develop solutions.

Recounting all of the inventions that have impacted humankind could fill a library. Let's look at three "historical" inventors and their inventions to see how they changed our world.



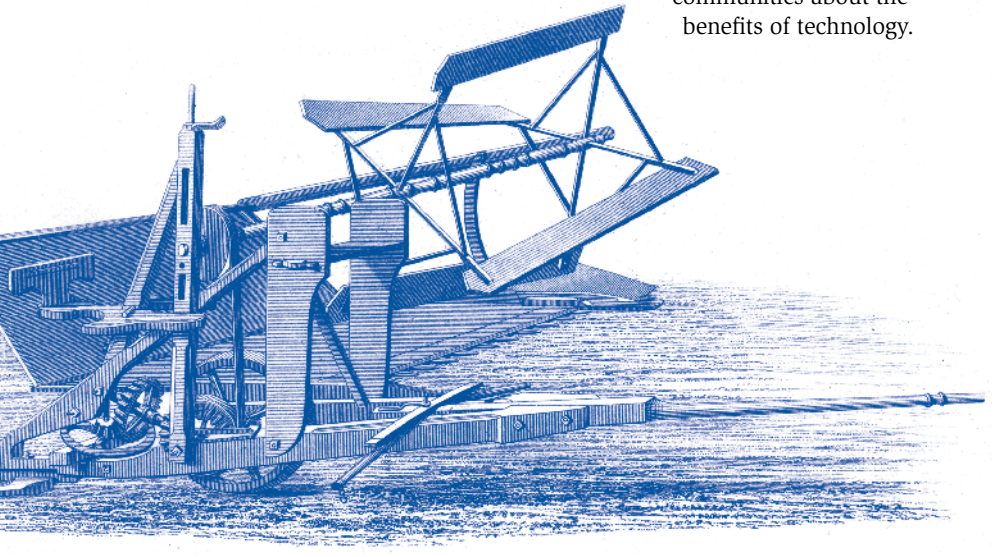
Cyrus McCormick invented the mechanical reaper, which resulted in a revolutionary breakthrough in agriculture.

Cyrus McCormick (1809–1884)

Cyrus McCormick is called the "father of modern agriculture" because he invented the first successful mechanical reaper in 1831 when he was 22 years old. With his reaper, McCormick single-handedly increased the potential yield of farming at least tenfold, with a minimum of effort by farmers. The reaper was the beginning of a new mechanical harvesting industry that made significant contributions to the prosperity of Americans.

Cyrus had a talent for agriculture and invention at an early age. When he was 15, he invented a lightweight cradle for carting harvested grain. The mechanical reaper was actually a project on which his father, also an inventor, had given up. Cyrus used his father's incomplete model as a starting point. He sketched plans for a machine that would automatically cut, thresh, and bundle grain while being pulled through a field by horses. Within six weeks—before the 1831 harvest was over—he had built, field-tested, remodeled, and successfully demonstrated to the public the world's first mechanical reaper.

Farmers were initially uninterested in the mechanical reaper, and for nine years there were virtually no sales, probably because farmers were reluctant to change what they knew. Undaunted, McCormick spent 10 years making improvements and was awarded his first patent in 1834. He also utilized novel business practices, including lenient credit for purchases, written performance guarantees ("15 acres a day"), readily available replacement parts, and advertising to educate farming communities about the benefits of technology.



Henry Ford (1863–1947)

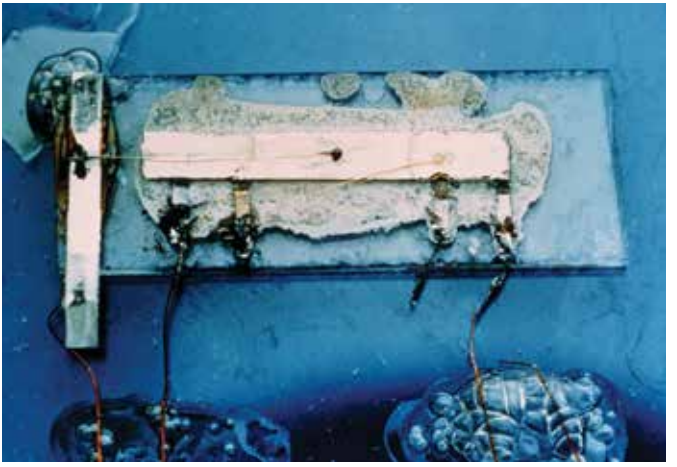
Henry Ford did not invent the automobile. That honor goes to Karl Benz (1844–1929) of Germany. Ford gained fame, however, for his pioneering achievements in the automobile industry, and he held many patents on automotive mechanisms. From boyhood he was interested in machinery, and after experimenting for several years in his spare time, he finished building his first automobile in 1893. Ten years later, he founded the Ford Motor Company.

In 1908, the company began selling Ford's Model T for $850. Sturdy, reliable, and easy to operate, the Model T quickly became popular, and Ford soon found he was unable to meet the demand for his cars.

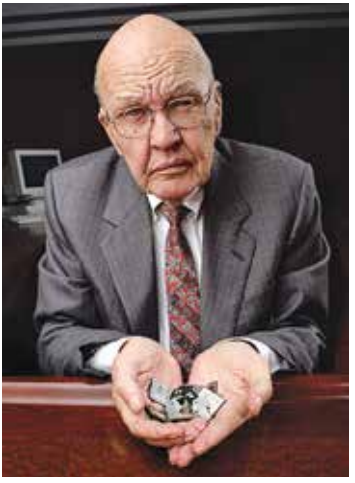
In 1913, Ford began using standardized parts and a moving assembly line in his factory. Now his employees built cars one piece at a time instead of one car at a time. Each worker could focus on doing one thing very well, rather than being responsible for a number of tasks. Ford did not invent the assembly line, nor was he the first to use it. He is generally credited, however, with its general adoption for large-scale manufacturing.

Ford's innovations helped to raise the American standard of living. The new assembly system produced cars quickly and efficiently—so efficiently that the cost of building cars was lowered considerably. He passed this savings along to his customers, and in 1915, he dropped the price of the Model T to $290. That year, Ford sold the millionth Model T.

Henry Ford's adoption of the moving assembly line transformed the automobile from an expensive luxury into a practical vehicle that working people could afford.



Jack Kilby invented the integrated circuit at Texas Instruments in 1958. Composed of only a transistor and other components on a slice of germanium, Kilby's invention, 7/16 by 1/16 inches in size, revolutionized the electronics industry and our lives.



Jack Kilby (1923–2005)

For one invention alone, Jack Kilby can be justly considered one of the greatest electrical engineers of all time. He invented the *monolithic integrated circuit,* or *microchip,* which made *microprocessors* possible, thereby allowing high-speed computing and communications systems to become efficient, convenient, affordable, and used everywhere.

After earning a Bachelor of Science degree in electrical engineering at the University of Illinois in 1947 and a Master of Science degree in electrical engineering at the University of Wisconsin in 1950, Kilby took a research position with Texas Instruments Inc. in Dallas, Texas. Within one year, Kilby had conceived and created a small, self-contained, *monolithic integrated circuit* in a single piece of semiconductor material about the size of a fingernail. At the first professional presentation of his invention at the Institute of Radio Engineers Show of 1959, Kilby's colleagues were both astonished and overjoyed—and a new generation of computers and microelectronics was born.

Kilby went on to develop the first industrial, commercial, and military applications for his integrated circuits—including the first pocket calculator (the Pocketronic) and the first computer in which the integrated circuit was used. By the mid-1970s, the microchip formed the basis of modern microelectronics. Without it, no personal computer, fax machine, cell phone, satellite television, or any other computer or mass communication system would exist.

For his invention of the integrated circuit, Kilby was awarded the Nobel Prize in Physics in 2000. Also credited with the invention of the thermal printer and the handheld calculator, Kilby had patented more than 60 inventions.

The breadboard (construction base) for the first electronic hand-held calculator fills a room.

Cyrus McCormick, Henry Ford, and Jack Kilby all solved important problems with technological solutions. Their solutions significantly impacted the quality of life, standard of living, and nature of modern society.

Inventors in the Community

Inventions can help people live longer, be more comfortable, and lead more productive lives. For these and other reasons, it's easy to see that inventors are important members of the community.

Can you locate an inventor in your community? Listed below are a few suggestions to help you.

- Ask the reference librarian at your local library.
- Talk to an engineer or entrepreneur.
- Call a local manufacturing business.
- Use the internet (always with your parent's permission first).

The internet can "bring the world" to you. It is a tool to be used appropriately to gain information while avoiding dangers. Websites that will help you locate inventors in your local community are listed in the resources section. Before you send an email to an organization asking for information, be sure you have your parent's permission to do so.

Researching Patents

One way to locate inventors living in your community is to research a *patent*. Inventors can legally protect their inventions, just as McCormick, Ford, and Kilby did, by patenting them with the U.S. Patent and Trademark Office (USPTO).

The Scouts BSA handbook and the *Digital Technology* merit badge pamphlet include tips on avoiding internet dangers.

Patents give the inventor the "right to exclude others from making, selling, or using" the invention. Anyone who tries to benefit financially from someone else's patented invention, or uses it without licensing it from the patent owner, can be found guilty of *patent infringement*, and may be required by law to pay the inventor a royalty, lost profits, and maybe even punitive damages.

Through the U.S. Patent and Trademark Office, inventors can obtain legal protection for a period of time in exchange for sharing their ideas with the public. In the United States, current patent laws generally grant protection for 20 years from the date the patent application is filed with the USPTO.

One important purpose of the patent system is to help inventors justify the effort and expense of making something that is new and useful. Some inventions, like new pharmaceutical drugs, can cost millions of dollars and take years to develop, so the prospect of getting a patent that excludes others from making and selling the drug offers an incentive for companies to invest in the necessary research and development.

Patents are explained in detail under "Intellectual Property, Patents, and Trademarks," later in this pamphlet.

FPO

FPO—FreePatentsOnline.com—is a free patent search engine that is fast and easy. (You can find some of the most crazy patents.) To search for a patent that was granted to an inventor in your community, use the Quick Search tab and fill in the name of your city and state. Be sure you have your parent's permission first.

Designing and building Pinewood Derby cars involves solving many problems, but Pinewood Derby cars are not inventions because they are not unique solutions.

From Problem-Solving to Inventing

Scouts solve problems all the time. If you sprain your ankle while hiking, your Scout patrol can make a crutch for you by using a tree branch. Three ropes, a few lashings, and wood supports become a bridge to cross over a bog. Remember the Pinewood Derby races from Cub Scouting? Building a Pinewood Derby car was all about solving problems in order to be the fastest 5-ounce car made from a block of pine with four nails for axles and plastic wheels. While Pinewood Derby cars are solutions, they are not inventions. Why? Because they are not *unique* solutions.

Invention is at one end of the problem-solving spectrum; **routine problem-solving** is at the other end. As you move toward invention, you are moving away from predictable and specific solutions. By creatively thinking about a problem, you can find a unique solution. Sometimes, this creative thinking becomes breakthrough thinking (a *Eureka!* moment) when you connect the problem you are trying to solve with something from an unrelated area.

The spectrum of problem-solving

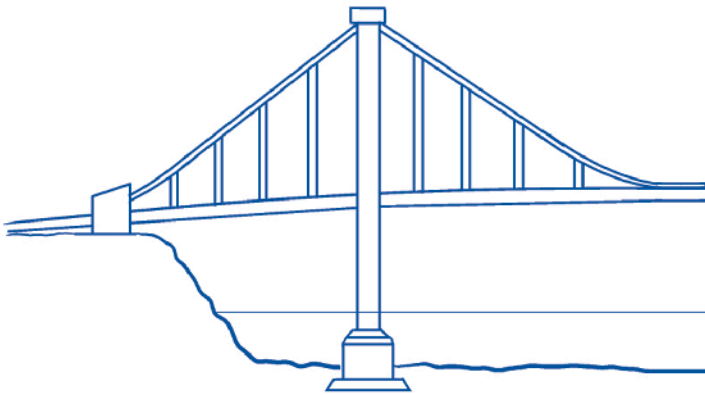
From Bridges to Backpacks

John Fabel was an inventor whose creative thinking about a problem led to a breakthrough. John was trained as a geographer and designer. His work as an inventor involved environment, community, and design. As a child, he continually asked ***What if*** questions: ***What if*** *I could make this work better?* ***What if*** *I built this?*

By creatively thinking about a problem, you can find a unique solution. Sometimes, this creative thinking becomes break-through thinking when you connect the problem with something totally unrelated.

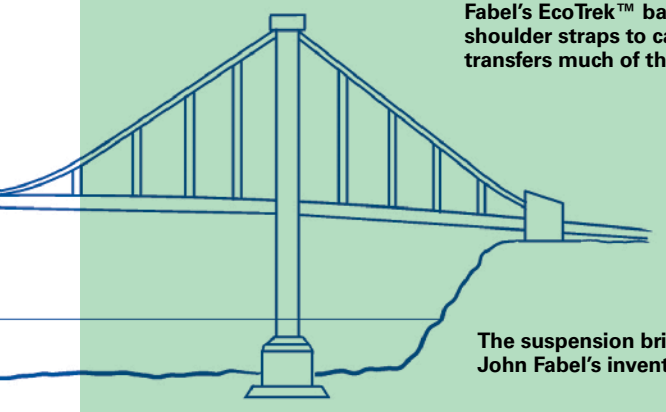
Because of the way he looked at problems, he was able to see a connection between the suspension bridges he saw in New York City and the problem he was trying to solve. This thought process led him to design a backpack that would distribute weight evenly so that after long hours of cross-country skiing, the straps of his backpack wouldn't bruise his shoulders. That is *breakthrough thinking,* sometimes referred to as a *Eureka!* moment.

The EcoTrek™ backpack that John Fabel invented does not rely on shoulder straps to carry the load. It transfers much of the weight to the hips. When wearing it, your hips act like a tower on a suspension bridge, and the backpack is similar to the roadway. Like cables on the bridge, the triangular flap between the backpack and the hip belt helps distribute the weight evenly. John filed for a patent on his backpack design in 1995. It was granted in 1997. Initially, he manufactured and sold his backpack directly to customers, but eventually he licensed the design to Marmot, a maker of backpacks, tents, sleeping bags, and outdoor clothing.



Inventor John Fabel was a Scout in western Massachusetts, as were his father and grandfather.

Fabel's EcoTrek™ backpack does not rely on shoulder straps to carry the load because it transfers much of the weight to the hips.



The suspension bridge helped inspire John Fabel's invention.

Who Says You Can't Rappel…in Reverse?

Nate Ball had a passion for inventing long before he could define the word. He recalls that at age 2, he dug up the family garden to build, wreck, and rebuild mud dams and underground forts. In the fourth grade, he created a bottle rocket launcher that shot two-liter bottles of water 100 feet into the sky. This creation was followed in sixth grade by a hovercraft powered by a vacuum cleaner motor.

Nate Ball using the ATLAS Powered Rope Ascender

By the eighth grade, he was attempting to build a Tesla coil in his parents' garage, making capacitors out of glass bottles and aluminum foil. "I saw Tesla coils on the internet shooting lightning," said Ball. "It was the coolest thing I'd ever seen, and I knew I had to build one." Amazingly, Ball did not touch a machine tool until he was in college. He credits limited resources during his early years with forming his ability to think unconventionally about problems and to come up with efficient solutions.

In 2004, along with three other mechanical engineering students at the Massachusetts Institute of Technology, Ball founded Atlas Devices, LLC. The goal of the company was to develop and commercialize the ATLAS Powered Rope Ascender, which uses a rope-handling mechanism, conceived by Ball. This portable device can raise more than 250 pounds at 10 feet per second, giving rescuers, emergency personnel, and soldiers faster and more controllable climbing capabilities. The U.S. Army awarded funding for this invention.

Ball is a coapplicant of multiple patents. His awards and achievements include the SAIC Award in the 2005 Soldier Design Competition, sponsored by the Institute for Soldier Nanotechnologies at the Massachusetts Institute of Technology, for his team's ATLAS Powered Rope Ascender. He also won the Luis De Florez Design and Innovation Award in 2005 for outstanding ingenuity and creativity from MIT's Department of Mechanical Engineering for an electric scooter. Nate Ball received his undergraduate and graduate degrees in mechanical engineering from MIT.

In 2015, Ball was named chief executive officer of Atlas Devices, which is now a global provider of innovative solutions for security, defense, and rescue operations. The company provides high-tech jobs for products that are 100% made in the United States. In addition to leading the company he co-founded with Eagle Scout Dan Walker, he is also a children's book author, host and producer of the PBS series *Design Squad*, and dedicated to inspiring youths of all ages to consider STEM careers and inventing solutions to real-world problems.

Inventor Nate Ball demonstrates reverse rappelling over a pool using the patented ATLAS Powered Rope Ascender. Nate was awarded the $30,000 Lemelson-MIT Student Prize in 2007 for his inventiveness. Today, Nate and his co-founder have built a successful business out of their invention. Their products help people do dangerous jobs more safely.

A Street-Legal Airplane

Carl Dietrich traces his earliest design innovations to his childhood, building tree forts in his backyard and elaborate spaceships from Fisher-Price® Construx building sets. He credits his father's fascination with model planes as the inspiration that led to his passion for aeronautics and aerospace. By the time Dietrich entered high school, his inventive drive had produced remote-controlled airplanes and designs for a hydrogen-powered aircraft.

Dietrich earned his undergraduate and graduate degrees from MIT, including a Ph.D. in 2006 in aeronautics and astronautics. His doctoral work led to an efficiency improvement design that he patented for a desktop-size Penning Fusion Reactor, following a research internship at Los Alamos National Laboratory in 2002. Carl Dietrich credits this internship with sparking his initial curiosity about a distributed network of reactors that could potentially replace the strained power grid of the United States.

In 1998, Dietrich cofounded the MIT Rocket Team. He holds a patent for his Centrifugal Direct Injection Engine—a low-cost, high-performance rocket propulsion engine. The CDIE operates without a conventional turbo pump pressurization system, which greatly reduces its complexity and cost.

He also invented the PickProd—a blast-safe demining pick for safer removal of antipersonnel landmines in environments with hard-packed earth, like Afghanistan. He made the decision **not to patent his invention, so it could be used by anyone in need.**

"The best way to think of an invention is to think of a need," says inventor Carl Dietrich.

The Transition's folding wings are the unique invention that make it different from a flying car.

In 2006, Carl Dietrich and four MIT colleagues (and fellow pilots) launched a start-up company called Terrafugia to create the **Transition,** a personal air vehicle (or PAV) concept. The Transition completed its flight test program in June 2009. It will make use of the nation's thousands of underutilized public-access airports by providing a practical transportation alternative to travelers whose destinations are 100 to 500 miles away. The Transition vehicle can be driven on any type of surfaced road, requires only a sport pilot's license to fly, and operates on premium unleaded gasoline. According to Dietrich, it's not a flying car; it's a road-able aircraft.

Carl Dietrich has two patents pending for the Transition, including overall configuration and a load-bearing hinge for the foldable wings.

Inventors in Your Community

As previously described, the internet can help you find inventors in your local community by researching their patents. Inventors may choose to patent their inventions in order to protect their creations. They may find out how to apply for and receive a patent through the U.S. Patent and Trademark Office. When a patent is granted by the U.S. government, the invention receives a U.S. Patent number. While you can search for patents on the U.S. Patent and Trademark Office website, there are other websites that might be easier to use.

Remember to always have your parent's permission *before* you use the internet.

patents.google.com

This site is easy to use, particularly if you already have the U.S. patent number, inventor name or other keywords. You can search patents from the U.S. Patent and Trademark Office, view the patent and accompanying images, and download patents.

FPO (FreePatentsOnline)

The FreePatentsOnline.com site allows users to easily search by the inventor's geographical location. Searches also can be conducted chronologically beginning with the most recent dates. To search, use the "expert" or "quick" functions. You will not be required to create a free account.

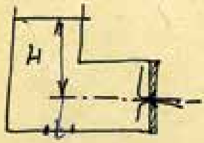
U.S. Patent and Trademark Office

The U.S. Patent and Trademark Office is the definitive site for all official patent and *trademark* issues. The site informs the public about patents, trademarks, and intellectual property law. Searching for patents on this powerful website is a more complicated process than searching on Google or FreePatentsOnline. The U.S. Patent and Trademark Office offers an eight-step patent process. Check out the information on the Patent Pro Bono Program, free for independent inventors. uspto.gov/patents/basics/using-legal-services/pro-bono/patent-pro-bono-program

№ 6.

Определение коэф. истечения.

явл. инверсии струи. — сжатие струи.



ε — коэф. сжатия.

$$\varepsilon = \frac{F_{сж.вес.}}{F_{отв}} = \frac{d_{гор} \cdot d_{верт} \cdot \pi}{4 \cdot \pi d_0^2} = \frac{d_г d_в}{d_0^2}$$

μ — коэф. расхода.

$$\mu = \frac{Q_д}{Q_т}; \quad Q_д = \frac{W}{t};$$

$$Q_т = F\sqrt{2gH}$$

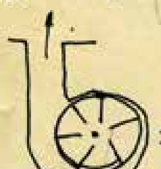
$$\frac{v_д}{v_т} = \varphi \text{ — коэф. скорости} = \frac{\mu}{\varepsilon};$$

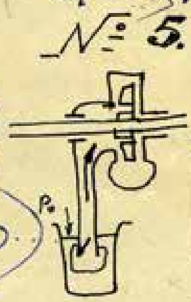
$v = \varphi\sqrt{2gH}$

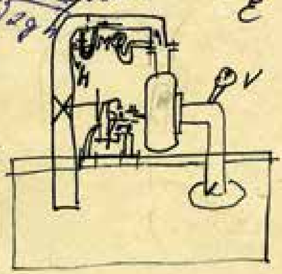
$Q = \mu \cdot F \cdot \sqrt{2gH}$

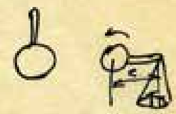
$\mu = \frac{Q_д}{Q_т}$

№ 5.









28 / 380

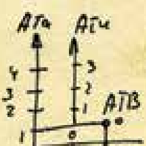
$N_д = M \cdot \omega$

$M = P \cdot \ell \quad \omega = \frac{\pi n}{30}$

$N_д = \frac{P \cdot \ell \cdot \pi \cdot n}{30}$

$N_н = Q \cdot \gamma \cdot H$

H — напор насоса.



$$N_д = \frac{p \cdot \ell \cdot \pi \cdot n}{30}$$

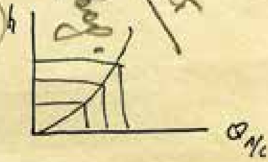
$$M = P \cdot \ell; \quad \omega = \frac{\pi \cdot n}{30}$$

$$z_1 + \frac{p_1}{\gamma} + \frac{v_1^2}{2g} = z_2 + \frac{p_2}{\gamma} + \frac{v_2^2}{2g} - H,$$

$$H = z_2 + \frac{p_2}{\gamma} - \frac{p_1}{\gamma}$$

$$H_{вакс} = \frac{h_{рт} \cdot \gamma_{рт}}{\gamma_в}$$

Нам вод = Н [illegible] / вод



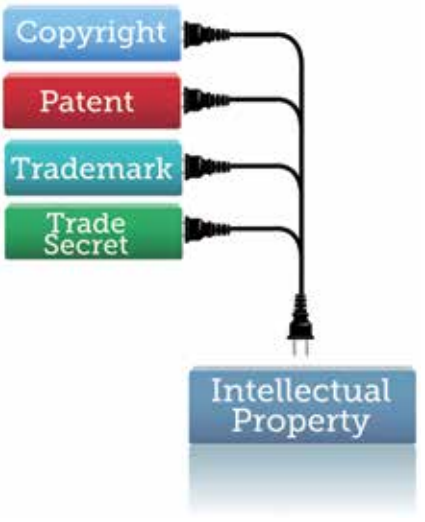
Intellectual Property, Patents, and Trademarks

It is important to be familiar with the laws of the United States that protect the property of inventors. The contributions of inventors result in a better quality of life for others in our society, and those inventors have the right to enjoy the financial benefits derived from their hard work and persistence in solving problems that lead to invention and innovation.

What Is Intellectual Property?

"Intellectual property" is a legal term that includes *patents* (which protect inventions), *trademarks* (which indicate a source of goods or services), *copyrights* (which protect the works of authors and artists), and *trade secrets* (secret knowledge that is used in business). Because you cannot touch, feel, smell, or taste a patent, trademark, copyright, or trade secret, these are often called "intangible." Nevertheless, such intangible things have value in the same way that physical property, such as land, houses, or cars, has value.

Different government agencies have the job of helping creative people establish their rights to their intellectual property. The U.S. Patent and Trademark Office, as the name implies, grants patents on inventions and registers trademarks. Copyrights can be registered in the Copyright Office, a part of the Library of Congress.



What Is a Patent?

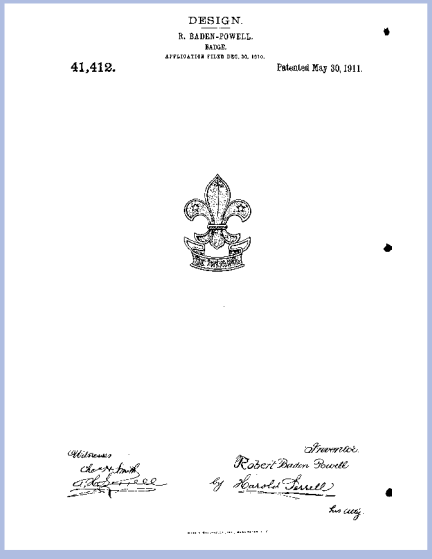
A patent protects an invention by giving the inventor the right to stop other people from making, using, or selling the patented invention. The word *patent* means *open*, and that describes the "deal"—in return for the patent, the inventor must be open about what his or her invention is, so that society can benefit from the inventor's knowledge. The inventor gives up secrecy and gets protection for a period of time. Everyone else gives up the ability to make, use, or sell the invention during the *patent term* (period of time), but they will know about it and will be able to use that knowledge, perhaps to make even better inventions in the future.

If someone else makes, uses, or sells the patented invention during the term of the patent without permission, he or she has *infringed* the patent. The owner of the patent can sue the infringer, asking a court to issue an *injunction* ordering the infringer to stop the infringement or asking the court to order the infringer to pay money. A monetary award can be either *actual damages* (the profits the patent owner might have made from selling the product or the profits the infringer has made from the infringement) or *punitive damages* (money that punishes the infringer).

There is no such thing as a "worldwide patent." Each country has its own patent system, and each country's patents are effective only in the country that issued the patent. A few regional patents cover a number of countries, such as the European Patent Convention for 27 European countries, ARIPO and OAPI in Africa, and the Eurasian Patent in some former Soviet countries. Inventors who want protection in more than one country will need to obtain a patent in each country or get a regional patent covering several countries.

As mentioned before, the part of the United States government that is responsible for issuing patents to inventors is the U.S. Patent and Trademark Office, a part of the Department of Commerce. The inventor files a patent application with the USPTO. The application describes the invention in detail complete enough that a person could build the invention from the description. The application is reviewed by a patent examiner, who will search earlier patents and patent applications to see whether anyone had already invented the invention. If the examiner decides the invention is new, the patent is issued. It remains "alive" for a term of 20 years from the date the application was filed, as long as the inventor pays the USPTO maintenance fees four, eight, and 12 years after the patent is issued.

1. *Utility patents* cover machines, products (articles of manufacture), methods (processes), compositions of matter (chemicals, cell lines), or improvements to any of these things. When people talk about a "patent"—including most of the discussions in this pamphlet—they usually mean a utility patent; this is the most common type. An example of this type of patent is number 7,581,715, for a "Powered Rope Ascender and Portable Rope Pulling Device" owned by Atlas Devices and invented by Nathan Ball and others. This patent is shown later in this chapter.
2. *Design patents* cover the appearance of useful objects. These patents do not cover the function or construction of the object. An example of a design patent is D41,412, issued in 1911 to Robert Baden-Powell for the design of the Scout badge.



DESIGN.

R. BADEN-POWELL.

BADGE.

APPLICATION FILED DEC. 30, 1910.

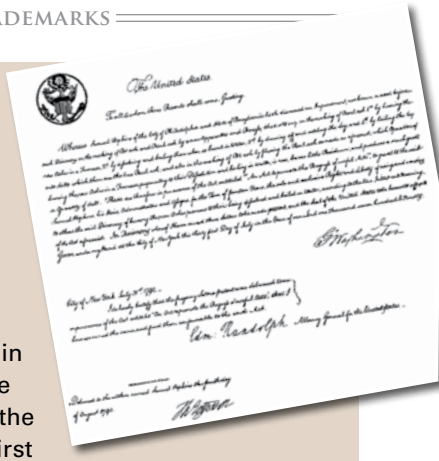
41,412. Patented May 30, 1911.

Witnesses:

Inventor:
Robert Baden Powell
by Harold Powell
his atty.

A design patent for Robert Baden-Powell's design of the Scout badge

3. *Plant patents* cover plants that are asexually reproduced (that is, plants that are grown from cuttings or rootstock rather than from seeds or bulbs). An example of a plant patent is PP13,286, owned by the University of California, for an "Almond tree named 'Winters'" developed by Professor Dale Kester and others at UC Davis.



Even at the very beginning of our country's history, the value of protecting intellectual property was recognized. The first patent in what is today the U.S. was issued long before we were a country. A "Method of Making Scythes" was patented in 1646 by the Massachusetts Bay Colony.

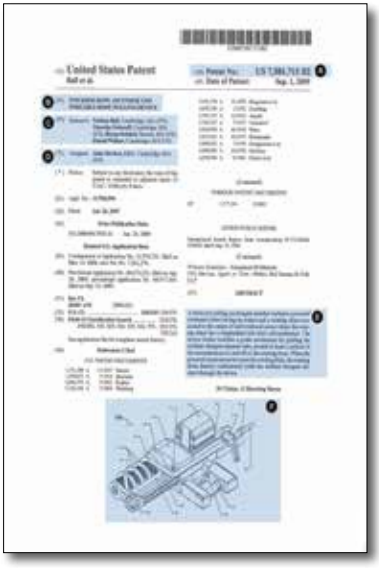
When the U.S. Constitution was written in 1787, the framers included a requirement in Article 1 to "promote the progress of science and useful arts by securing for ... inventors the exclusive right to their ... discoveries." The first patent issued by the United States of America in 1790 is shown here. Protecting a method of making potash and pearl ash for fertilizer, it was examined by Thomas Jefferson and signed by George Washington.

While that is the first U.S. patent, it isn't "patent No. 1." Patents were not numbered until 1836, when John Ruggles received patent No. 1 on "Traction Wheels." More than 10 million patents have been issued since 1790.

Components of a Patent

Patents reveal treasure troves of information. Because one of the requirements for a patent is **full disclosure of the invention,** you can read detailed information as to how a particular technology works. Most technical information found in patents does not exist anywhere else, so the USPTO is an excellent place to learn about how things work.

After the current numbering system for patents was established in 1836, the first design patent was granted in 1842, and the first plant patent in 1931.



This patent, granted to inventor Nathan Ball on Sept. 1, 2009, is U.S. Patent 7,581,715 for the Powered Rope Ascender and Portable Rope Pulling Device.

The basic parts of U.S. patent 7,581,715 are:

A	Patent Number	7,581,715	Unique number issued by USPTO within each class of patents (utility, design, plant)
B	Title	POWERED ROPE ASCENDER AND PORTABLE ROPE PULLING DEVICE	Technical title of the invention
C	Inventors	Nathan Ball Timothy Fofonoff Bryan Schmid Daniel Walker	Four inventors are listed for this invention.
D	Assignee	Atlas Devices, LLC	The assignee is the owner of the patent.
E	Abstract		Short, one-paragraph overview of the invention
F	Drawings	11 drawing sheets or figures	
	Description	A detailed description of the invention begins in column 3, line 47, and ends in column 9, line 51.	The description should fully disclose the technical details of the invention so that someone skilled and knowledgeable could build or make it. Patents do not have page numbers but rather column and line numbers.
	Claims	The 20 claims begin in column 9, line 52, and end in column 12, line 10.	The claims set out exactly what the patent protects. Claims are like an outline, determining the "legal boundary" of the patented invention.

Trademarks

A trademark is something used to identify the source of a particular product or service. Trademarks originally came from the "hallmarks" that early metalsmiths stamped into their work to show who had made the pieces and to guarantee the purity of the metal. Today, nearly anything that can distinguish one maker's goods or services from those of a competitor can be considered a trademark. Familiar examples include:

- A word or name—"Exxon" for petroleum products, or "Eagle Scout" as an indication of rank in Scouting America
- A phrase or slogan—"Just Do It" for sneakers (Nike), or "Prepared. For Life." for "promoting the interests of members of a youth development and community service organization" (the BSA)
- A way of presenting a word—the striped IBM logo, or Walt Disney's signature on films
- A symbol or drawing (logo)—the apple on Apple computers, or the Order of the Arrow arrow for sashes
- A character—Mr. Peanut for nuts (Kraft), or the Energizer Bunny for batteries
- A shape—the curved and ribbed Coca-Cola bottle
- A distinctive building design—KFC's striped roof, or McDonald's Golden Arches
- Details of packaging ("trade dress")—the square, textured, silver-foil wrapper on Klondike ice cream bars, or the red-and-white label on Campbell's soup cans
- In rare instances, things such as a sound, color, piece of music, and even a smell (in one case, for scented sewing thread)

Placing a superscript "TM" (™) next to the mark tells others that the owner is claiming trademark rights. If the owner of a mark registers it with the U.S. Patent and Trademark Office, the owner of the mark may use the symbol ® to show that the trademark has been registered.

The trademark is visible on this lantern sold by the Coleman Company.

Coleman®

You may be familiar with trademarks from your camping gear. For instance, the Coleman Company Inc. of Wichita, Kansas, owns this trademarked design for recreational sports equipment.

Requirements for Patentability

You can get a patent if (a) your invention is one of the types of things the patent law says is protectable—a machine or product, a method of doing something, or a "composition of matter"; (b) you can describe your invention well enough that it can be built from your description (if you can't explain how a working model would be built, you have an idea, not an invention); and (c) the invention meets the requirements for patentability.

The three major requirements for patentability are that the invention must be *novel, useful,* and *not obvious*.

- "Novel" means that no one has previously patented the invention, described it in a publication, used it in public, or sold it. All of these conditions also apply to your own actions more than one year before you apply for a patent. In other words, if you ever want patent protection, you have one year from your first public disclosure to apply for a patent.
- "Useful" generally means the invention would work to do something—anything at all. As long as you can explain what your invention does, it is considered "useful." Very few patent applications are rejected on the grounds of "not useful"—mostly so-called "perpetual motion" inventions or chemical compounds and gene sequences with no known use. If you think you have invented something as apparently impossible as a perpetual motion machine, the Patent Office will expect you to prove it with a working model.
- "Not obvious" means the invention must not be an obvious combination of things that are already known. This is often hard to define—every invention seems obvious, after it has been invented. The question is what the combination of known things would have taught a hypothetical "person having ordinary skill in the art" before the invention was created. That is, your invention is deemed to be "obvious" if a person with "skill in the art" would have thought to combine the previously existing inventions to result in your invention without first having seen your patent application.

The technical information contained in a patent often cannot be found anywhere else.

Unpatented Inventions

Not all inventions are patented. Some cannot be patented because they are not patentable subject matter.

For an invention that is otherwise patentable, however, the reasons for not getting a patent are often economic. The inventor might decide that he or she will not be able to make enough money from the invention to pay for the patent, or it is so easy and cheap to copy the invention that the market would quickly be flooded by competitors who would disappear before the inventor could stop them.

The decision not to patent could also be related to timing. On average, it takes three or more years to get a patent. If the invention is the kind of thing that will be a big hit in the short run but unfashionable within three years, patenting it would be a waste of money. For example, when the patent application on the hula hoop was filed in 1958, every kid wanted one. More than 100 million of the plastic hoops were sold that year. But by the time patent number 3,079,728 was issued on March 5, 1963, the craze had long since passed.

Still other inventions are not patented because they are more valuable if some part of them is kept secret. For example, the formula for Coca-Cola® is still a well-kept trade secret. If Atlanta pharmacist John Pemberton had patented the soda when he developed it in 1886, the formula would have been published in the issued patent. Pemberton might have been able to stop imitators for 17 years (the term of patent protection at the time), but after that everyone would have been able to make identical drinks.

Jonas Salk (1914–1995) created the first polio vaccine—one of the most important vaccines of the 20th century—and chose not to patent it. Polio is an infectious viral disease that attacks nerve cells and sometimes the central nervous system, causing paralysis, permanent disability and deformity, and in some cases death. It is estimated that Salk's decision not to patent the vaccine cost him $7 billion in profits, but he was acclaimed as an international hero.

Inventors sometimes make their inventions available without patenting them because they believe the invention will be of more benefit to society and people if it is freely available.

Inventors As Humanitarians

Inventors may choose not to patent devices that can be of great help to people in need. This bicycle-powered device, which was field tested in Tanzania, shells corn 40 times faster than by hand. This frees people of manual labor and generates an income from the sale of excess corn kernels.

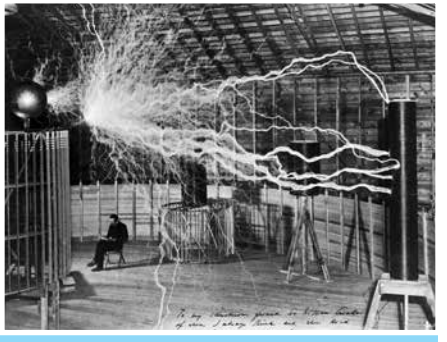
Nikola Tesla

Nikola Tesla (1856–1943) was a Serbian inventor and a pioneer in electric power. An experienced electrical engineer, Tesla immigrated to the United States in 1884 to work for Thomas Edison in New York City. He soon left Edison to set up his own laboratories and companies to develop electrical devices, including his patented alternating current (AC) motor, now used worldwide in industry and household appliances. In 1888, Tesla designed the first practical system of generating and transmitting alternating current for electric power. AC beat out DC (direct current) to become the form in which electric power is delivered to businesses and residences today.

Tesla also conducted experiments with radio waves and wireless communications. He patented the basic system of radio in 1896, and his published schematic diagrams described all the basic elements of the radio transmitter that was later used by Guglielmo Marconi. In 1898, Tesla demonstrated a remote-controlled boat, which may have been the first such radio-controlled device ever exhibited to the public.

Tesla's fondness for showmanship earned him a reputation as a kind of "mad scientist." At his laboratory in Colorado Springs, Colorado, he conducted spectacular high-voltage experiments, producing artificial lightning with discharges in the millions of volts and arcs up to 135 feet long.

His many inventions include the Tesla coil, a transformer used to produce huge voltages of high-frequency alternating current. Circuits related to the Tesla coil are still used in radio and television receivers. At least 275 patents were issued to Tesla in 26 countries, and he developed many other inventions that were not patented. In large part, his inventions and discoveries form the basis for much of the modern world's electrically powered lifestyle.



Nikola Tesla sat calmly reading in his Colorado Springs laboratory as his "magnifying transmitter" generated millions of volts of electricity and produced long, crackling arcs.

Famous Women Inventors

Among the inventors whose ingenuity has helped to shape the modern world are many women, some of them famous and some relatively unknown. Listed here are a few women inventors and their inventions.

Inventor	Invention	Year
Margaret Knight	Machine to produce flat-bottomed paper bags	1871
Mary Anderson	Windshield wipers	1903
Ruth Wakefield	Chocolate chip cookies	1930
Patsy Sherman	Scotchgard™ stain repellent	1956
Bette Nesmith Graham	Liquid Paper® correction fluid	1958
Stephanie Kwolek	Kevlar®, a synthetic material used in bulletproof vests	1971
Sally Fox	Machine-spinnable naturally colored cotton	1989

Stephanie Kwolek (1923–2014) invented Kevlar, widely used in the making of bulletproof vests. She once said, "I don't think there's anything like saving someone's life to bring you satisfaction and happiness."

Inventing Closer to Home

Each time you go camping, you take camping gear to keep you dry, help you prepare food, and find your way on hikes and watercraft trips. The products you rely on represent years of research, development, refinement, and input from numerous inventors. Many of these items are either patented or patent pending—meaning a patent application has been filed with the U.S. Patent and Trademark Office and is being processed. Below are examples of a few common camping items and their U.S. patent numbers.

Camping stove	U.S. Patent No. 5423308; patented in 1995
Tent with screen porch	U.S. Patent No. D418572; patented in 2000
Disposable rain poncho	U.S. Patent No. 3665518; patented in 1972
Tent with retractable fly	U.S. Patent No. 6499497; patented in 2002

When you prepare for a camping trip, do you consider the environmental conditions where you will be spending the night? What is the weather forecast? What do Scouts who have previously camped there recommend? Can you use gear made of particular material without harming the plants and animals that live nearby? Can you purchase environmentally friendly equipment to protect our planet?

The Scouting outdoor ethics are held in the highest regard. This means that, whenever possible, you and other Scouts should make every effort to minimize the environmental impact of your actions and the gear you use. As you make these considerations, you can think inventively to devise solutions to your problems—not least of which are issues concerning outdoor gear.

Think inventively about how to make your camping equipment more useful. What problems do you have with your equipment? Can you think of any solutions? While this might be routine problem-solving, it is an excellent way to start inventing.

How would you improve a mess kit?

How Would You Improve on These Items?

Mess Kit. As commonly used camping products, mess kits are subjected to heavy use and a variety of environmental conditions. If your mess kit shows signs of rust or bends easily, you might suggest that the manufacturer consider using different materials in its construction. When buying a mess kit, it is important to consider the material from which it is made. For example, if you camp in areas prone to extreme temperatures or heavy precipitation, you need gear that can withstand the conditions. Do you have suggestions for improving the durability of your mess kit? Do you have other suggestions for its improvement?

Collapsible Cup. Folding cups and collapsible mugs take up little space in a backpack, but they can be prone to collapsing at the wrong time—when they're full of liquid. Can you suggest improvements for stability? Might a different material be more durable? Might a different material provide better insulation for hot or cold drinks? Would a handle make the cup more functional?

How would you improve a collapsible cup?

Backpacking Tent. As you know, a tent is the quintessential piece of gear for overnight outings. However, you have probably had your share of tent troubles. You know how it feels to discover that a part is missing, there is a hole in the material, or the zipper is stuck, especially when you are setting up camp as it is getting dark or raining!

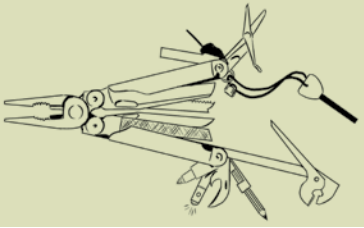
Depending on where you camp, your tent may perform better than other tents under certain environmental conditions than others. For example, some tent materials are sensitive to intense, direct sunlight. Others are made with material that deflects sunlight and maintains structural integrity. Based on your camping experiences, how would you improve your tent? Can you think of problems you have encountered and offer ideas as to how they might be fixed?

How would you improve your tent?

For more inventive solutions that are creative and unique (and less routine), consider unrelated things and how they could help you solve a problem with your camping equipment. Can you relate an umbrella or a bicycle pump to putting up a tent? What inspiration is there in nature for putting up a tent? Generate solutions by combining unrelated factors. Remember John Fabel's suspension backpack. What is your "bridge?"

Think inventively about improvements to your own gear. The following matrix might help spark ideas for making improvements to your camping gear.

	Current Usefulness	Improving Marketability and Appearance	Improving Function
Propane Lantern	Used for lighting entire camp area.	Different sizes needed; could use a transport case.	Needs a switch to turn on light. Needs to be adjustable for different light intensity. Needs to hang more easily.
Flashlight	Used when camping at night for making trips to tents, cabins, or bathrooms.	Choice of colors and sizes would be welcome.	Needs to be waterproof. Could be brighter with LEDs. Provide extra battery pack and bulbs with purchase.
Leatherman® Multi-Tool	Used as a screwdriver, can opener, and saw.	A selection of colors for easy identification would be beneficial. Add graphics; customize with name.	Additional features would be fire starter (lighter or magnesium stick). Pen/pencil would be useful. Flashlight with tools would be useful. Hot pot lifter. Wire strippers.
Hiking Shoes	Used for walking and hiking on varying types of terrain.	Different graphics on shoes, maybe camouflage.	Make boots fireproof. Cover with material that does not attract burrs.



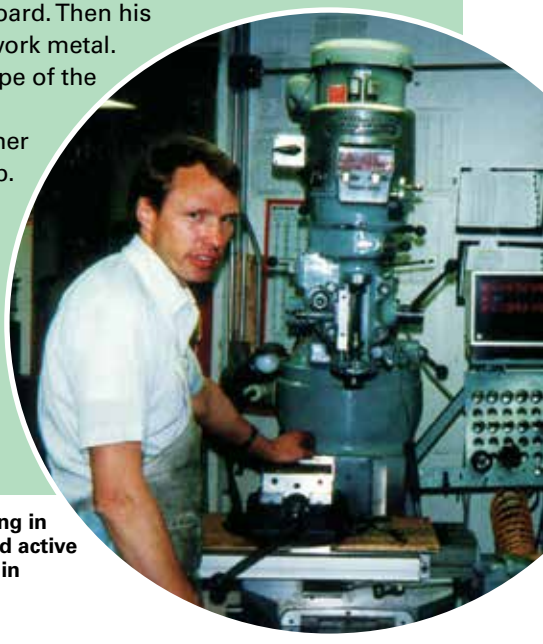
Scouts from Troop 4 in Brillion, Wisconsin, thought the functionality of a Leatherman multi-tool could be improved by adding a hot pot lifter and fire starter.

The Leatherman Multi-Tool Story

A Scout knife was not the right tool to fix an old Fiat. The multi-tool was dreamed up in 1975 by Tim Leatherman when he needed pliers but had only a pocketknife. Five years later, he was granted U.S. Patent 4,238,862 for a pocket multiple tool. His idea became reality in 1983, when two mail-order companies offered his multi-tool in their holiday catalogs.

Tim is an inventor, engineer, and entrepreneur. After earning his degree in mechanical engineering, he found work as an English teacher, a helicopter mechanic, and in other fields. After he dreamed up the multi-tool, he made models out of cardboard. Then his brother-in-law taught him how to work metal. Tim eventually built a steel prototype of the multi-tool in his garage.

Tim's road to success was neither quick nor easy, but he didn't give up. Today, the Leatherman Tool Group employs more than 400 people and makes more than a million tools a year. Leatherman tools are sold in more than 80 countries. There are 46 Leatherman tools for activities ranging from bicycling to camping, fishing to gardening, and even Scouting.



An early photo of Tim Leatherman working in his garage shop. Tim was a Life Scout and active in the Order of the Arrow from Troop 811 in Portland, Oregon.

A laboratory or engineering notebook is as important today as it was when Jack Kilby was recording his ideas for the microchip.

Record Your Ideas

It is important to keep a notebook of your ideas. When you see a problem that needs to be solved, write it down. What are you curious about? What bugs you? When you come across something that doesn't work the way it should, write down ways to make it better. Keep an Idea Matrix, like the one the Scouts from Brillion, Wisconsin, used for the improved Leatherman Multi-Tool. If you develop the habit of recording your ideas, you will never be at a loss for a good problem to work on solving.

As you record how you would solve a problem, your idea will move forward from an idea to something real.

America Invents Act: First to File

Any inventor who hasn't heard the phrase "first to file" should take note. In the past, inventorship was based on the "first to invent." Today, the America Invents Act gives priority to those who are the "first to file" a patent. Even if you kept a notebook and could prove you came up with an idea first, if someone else filed an application with the U.S. Patent and Trademark office before you, with few exceptions, you will be out of luck.

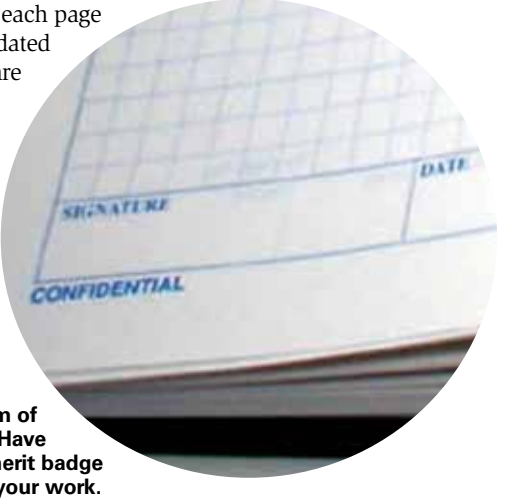
This change took effect in March 2013 to help inventors bring their creations to market sooner, among other outcomes. First to file also allows American inventors to protect their intellectual property abroad by making the patent process more efficient, predictable, and in line with the patent laws of the international community.

Since a notebook is a permanent record of your ideas, some thought should go into the form of your entries. Your notebook binding ideally should be sewn and not spiral bound, preventing pages from being easily torn out. Inexpensive composition books have sewn bindings, as do more expensive laboratory or engineering notebooks, available at office supply stores. Since drawings will be part of your record, grid paper is preferable to lined paper.

You often learn from your mistakes, so don't try to hide them. Mistakes may be valuable when you look back at your work.

Number and date each page of your notebook. Be sure to list dates chronologically and do not skip pages. After you have recorded your ideas and findings, add a suitable title to each page. Supplement your entries with hand sketches. If you add something printed to your notebook, tape it in securely. Handwriting should be neat and legible. All entries should be written with a pen, not a pencil. If you make a mistake, cross it out with a single line and add a note about what the error was. You cannot erase because you are using a pen. Don't use correction fluid.

It is important to have the bottom of each page in your notebook witnessed, signed, and dated by someone who understands what you are describing. Your Inventing merit badge counselor, science teacher, or perhaps an engineer are appropriate witnesses of your work. There are rules concerning the notebook as a permanent record for obtaining future intellectual property rights. So, early in your inventing career, get into the habit of keeping a notebook.



It is important to sign and date the bottom of each page in your engineering notebook. Have your ideas witnessed by your Inventing merit badge counselor or someone who understands your work.


BOY SCOUTS OF AMERICA
64
Troop 004
Brillion, WI

The Inventing Process

There are so many possibilities for inventions that will solve problems and improve human existence. But if someone asks you to invent "right now," your mind might very well draw a blank. In the inventing process, gather information, think about how to solve a problem, and narrow your focus. Here are a few tips to help you get started.

What to Invent

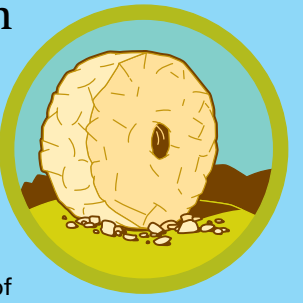
Inventing is probably easier when it involves items you use frequently, or activities you like to do or in which you have gained expertise. For example, you might like to ride horses. Have you noticed a problem in connection with your horseback riding experience? What about playing video games? Brushing your teeth? Would you like a better fire starter on campouts? Have you ever talked to your grandfather about his pocketknife options when he was a kid? Remember, Tim Leatherman's idea for the multi-tool occurred when his Scout knife would not do the trick to keep his old Fiat running.

How much more useful is the Leatherman Super Tool compared to a knife that was available to Scouts in 1911?

This is the Scout knife that the New York Knife Company made in 1911.

As you ponder possible inventions, use the activities you enjoy to think of "spin-off" ideas. For example, if you are a horseback rider, imagine how the experience of riding a horse could be improved. What about the care of horses when they are not being ridden? What about feeding, grooming, or training horses? What could you invent that might be useful in these spin-off areas? Perhaps your horse-care ideas might spin off into pet care of other types of animals. If you have a pet, wouldn't it be helpful if you didn't have to feed and water your pet every day? You could invent new ways of caring for your pet while you are away for the weekend.

Merit Badge Design



Illustrator and artist Nick Dragotta developed the concept behind the Inventing merit badge logo, which features a Stone Age–wheel. But who invented the wheel, and why was it invented?

Much of the early history of the wheel is not known because it was invented such a long time ago, in 5000 B.C. by ancient Mesopotamians. The wheel may be the very first technological invention. The earliest wheel was most likely for a potter's wheel. The technology of wheeled travel was invented around 3500 B.C., about the same time as the domestication of the horse.

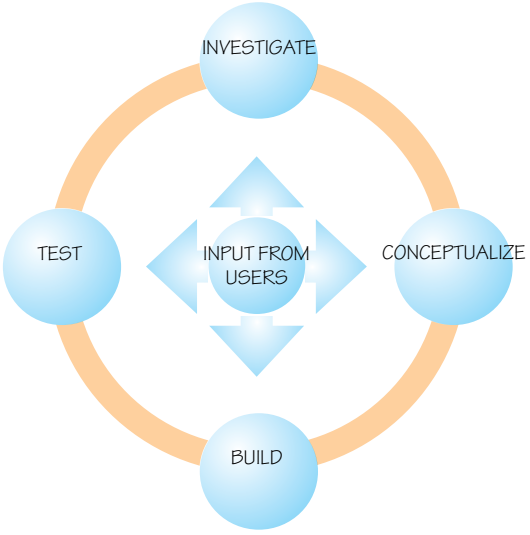
The wheel represents how something so basic and intuitively simple can have a profound effect on the history of humankind. What will Scouts invent, and what impact will their inventions have on the history of humankind?

List Your Ideas

As you think about possible inventions, list ideas in your invention notebook. Your list might begin like this:

1. Toothbrush that has a guard to keep hands dry and free from saliva
2. Portable toolbox/stool with handle and storage space for brushes and equipment used to groom my horse
3. A water bottle that doesn't need to be held when filtering water into it
4. Bicycle tires that never go flat
5. Self-cleaning fish tank

Once you have listed your ideas, discuss them with your parent, merit badge counselor, Scout patrol, and friends, and select your three favorite ideas. Think about how you would turn these ideas into inventions. Identify the ONE idea that would be fun and feasible to work on.



Inventing is a cycle; it is not a step-by-step process. Throughout the cycle, inventors get input from users or potential customers of the product they are inventing.

Scouts discussing ideas for water bottles and attachment devices at San Juan High School in Blanding, Utah.

Investigate

Remember that you will not be the only user of your invention. The most successful inventions affect tens, hundreds, or thousands of people. Think about how many people use water bottles: school children, athletes, campers, and hikers. Some water bottles are disposable. Some are easy to hold. Still others may be insulated.

What if the water bottle had been designed to be useful only to the person who invented it? Its usefulness would be severely limited. Your invention should be appealing and desired by a broad range of people. Ask potential users of your idea what they think would be important in your invention, and include more ideas than just your own. The people you interview should know something about the idea, be interested in it, and currently use something similar. If you want to design a new water bottle for hiking, talk to Scouts, hikers, backpackers, park service workers, sporting goods store employees, and professionals who use water bottles in their work. Ask questions like:

- When do you use a water bottle?
- How often do you use a water bottle?
- What kind of water bottle do you use? Why?
- If you could change something about your water bottle, what would it be?
- What kinds of negative experiences have you had when using a water bottle?

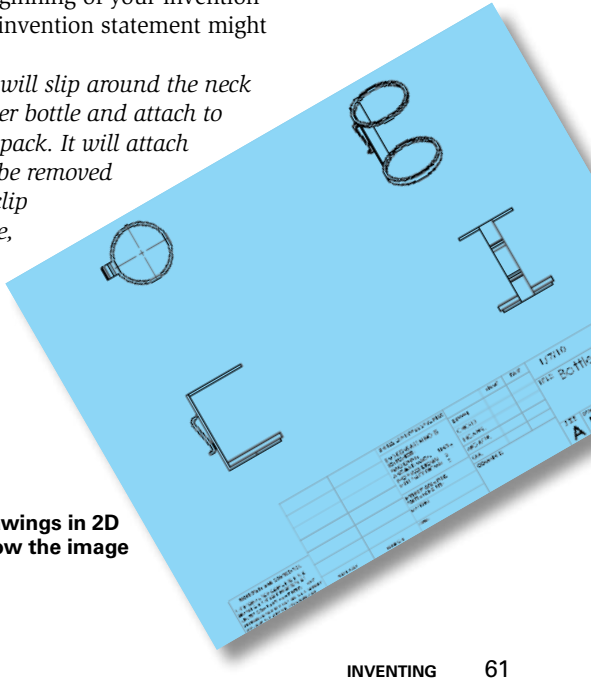
Record the answers in your invention notebook.

Conceptualize

After you gather information from users, conceptualize your ideas on paper, both in words and with sketches. Describe your idea so that those assisting you could build a model from your notes. Do not worry if you cannot draw as well as you would like. You will improve with practice.

Continuing with the example of the water bottle idea, one of the challenges backpackers face is trying to hold a water bottle while pumping fresh water, standing in a running river. Come up with performance criteria about what you want your invention to do. This is the beginning of your invention statement. An example of an early invention statement might read like this:

> *I am inventing a clip that will slip around the neck just under the lid of a water bottle and attach to a belt, waistband, or backpack. It will attach easily and firmly but can be removed with minimal effort. The clip will never fall off the bottle, making it possible for one person to easily refill a water bottle through a filter device in a stream or river.*



Water bottle clip in 2D CAD. Drawings in 2D CAD are usually printed and show the image as a 3-view drawing.

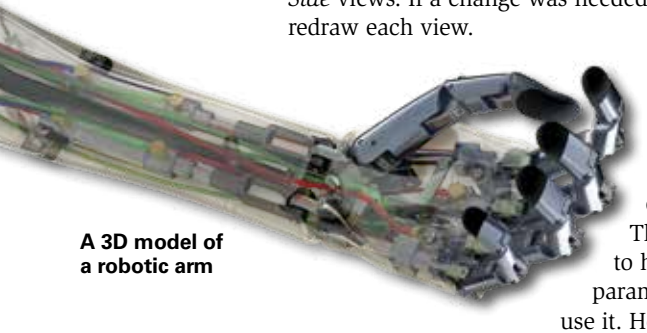
As you begin work on your invention, you will develop specifications based on what you and other users want. Record the specifications in your notebook. Add quantifiable terms to define your specifications. Use the invention statement to guide your development work. Modify the statement as you move through the invention process, as needed.

Although you don't have to be an artist, the drawing for an invention represents a critical piece of its description. Once you do your best sketch, have someone review it to determine whether you have visually and clearly communicated your invention.

Water bottle clip in 3D CAD. Today, almost all drawings are done in 3D as models.

Professional inventors use specific drawing techniques to communicate exactly what they want to build. These techniques follow critical guidelines regarding where things are and how to build them. This work, previously done by hand with pencil and drawing tools on drafting tables, has been done since the early 1980s in *2D* (two dimensions) on the computer or through powerful *computer-aided design (CAD)* software.

The old way to create a drawing was to simply draw each view separately on a single page in *Front, Top*, and *Side* views. If a change was needed, it was time-consuming to redraw each view.



A 3D model of a robotic arm

Today, when a 3D model is created, it can be changed in one drawing, the model, and printed out in three views. The new process is called *parametric modeling*. There is software available to help you learn more about parametric modeling and how to use it. However, for this merit badge, all you need is your notebook and a pencil. If you have never been exposed to technical drawing, you may want to earn the Drafting merit badge along with the Inventing merit badge.

Information on obtaining free access to SolidWorks® 3D CAD software is available in the resources section of this pamphlet. Enjoy experimenting with it. Have fun. Use the tutorials. However, be prepared to spend some time learning it well enough to build an invention from your 3D model.

Build a Model

For many, the model is one of the most enjoyable parts of the inventing process. It is a critical step. Building a model gives you the chance to experiment inexpensively with many issues so you can fine-tune your concept.

Professionals usually begin by building scale models of new things like boats, vehicles, or airplanes that are expensive to create. Inventor Carl Dietrich did not begin by building his "road-able aircraft" at full scale.

Since a new airplane takes years to make and costs millions of dollars, a lot of time is spent making models of everything from the body and instrument panel to the ailerons and landing gear. By making models, inventors can refine design and mechanical issues and correct mistakes and make improvements before building the final product.

Models can be made from a variety of materials: Clay, cardboard, wood, fabric, LEGO® blocks, metal conduit, and PVC pipe all are useful materials. Check out the trash. You will be amazed at what useful things you can find there.

One of Tim Leatherman's first models of a multi-tool was made of cardboard.

SR-71 *Blackbird* model

A model that accurately reflects the dimensions of a project at a reduced or enlarged size is called a scale model. For more information about scale, see the *Drafting* merit badge pamphlet.

Find A Problem To Solve

Inventor Linda Mentz, Eagle Scout

Linda Mentz, an Eagle Scout in Troop 21, Gainesville, Florida, is an inventor. Her Eagle project—a drying system for firefighters' gear—was widely publicized. People from all over the world reached out to her for information on her invention. She says she didn't realize she was inventing, though, until she had gotten through a lot of her Eagle project in the fall of 2020. When she started her project, she did research and knew what others had done to help solve the problem of drying the bulky gear firefighters wear. She saw images online of things that were similar to hers. "In a way, that was just the idea of the product. I thought of myself more as an inventor as I did more work, between the manipulation of the materials and taking measurements of air flow. I actually got my own ideas into the product I built," Linda says.

Like all inventors, Linda set out to understand the problem she was trying to solve. She observed how firefighters dried gear outdoors. She talked to her local fire departments. Eventually, the fire departments asked her to build her design. She drew designs and listed materials and instructions. With the help of her fellow Scouts, Scouters, and other adults, Linda built two dryers for four sets of gear each.

Linda delivered the bunker gear drying system to Gainesville Fire and Rescue Deputy Chief Rice, receiving the Chief's Award for Excellence. Scouts— and inventors —help others. Linda's invention helped firefighters to be safe and ready for the next emergency.

List Parts and Materials

When a model is complete and you are satisfied with the design, generate a list of the parts and types of materials for the actual invention. These lists will help you get an idea of how much it might cost to build the invention.

Parts List for Water Bottle Clip

Top ring	Ultrahigh Molecular Weight Polyethylene (UHMW PE)
Dimensions	Outside diameter, 2.4"; inside diameter, 2.2"; thickness, 0.125"
Base	UHMW PE Outside diameter, 2.4"; thickness, 0.125"
Back	Type 2024-T52 aluminum alloy Thickness, 0.10"; width, 0.75"; height, 5.0" To be stamped in shape shown on drawing
Clip	Type 2024-T52 aluminum alloy Thickness, 0.10"; width, 0.50"; length, 2.0" To be stamped in shape shown on drawing
Netting	5/16" plastic mesh; 1000/250 denier polyester Weight, 5.50 ounces per square yard Width, 5.0"; length, 6.5" To be thermally fused to top ring and base
Rivets	7 aluminum Diameter, 0.125"; length, 0.25" 3 rivets at top ring; 4 rivets at base

Test in the Field

The next step of the invention process is getting the best working model of your idea into the hands of potential users. Share your invention statement and model with users. This is called field-testing. Ask users for likes and dislikes about your model. Write those comments in your notebook and analyze them to see if you agree. Make a list of the things you would like to change when you build your next model.

Getting input from users is important. However, if you do not have access to users of your invention, share your model and invention statement with your Inventing merit badge counselor, and ask for feedback.

Meeting Personal Needs

Gihan Amarasiriwardena, an Eagle Scout from Troop 504, Great Trails Council (now the Western Massachusetts Council), was inspired to invent a piece of lawn care equipment that didn't exist. From fifth grade through high school, Gihan had a small business taking care of lawns in his neighborhood. He saw that he could save time and earn more money by doing two lawn maintenance chores simultaneously—mowing and trimming. With parts given to him by a local lawn mower repair shop, Gihan added a trimmer assembly to a push mower.

"To invent, you need a good imagination and a pile of junk." —Thomas A. Edison, inventor

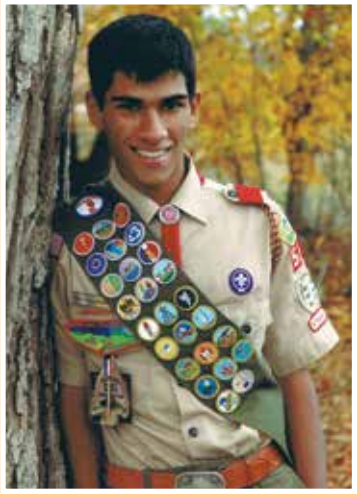
Always interested in building tree forts or simply creating things with Erector® construction sets, Gihan learned to work with his hands so he could turn his ideas into reality. After Scouting campouts, Gihan began to see the need for low-cost, high-performance outdoor gear. Prior to a trip to the Philmont Scout Ranch, he spent time with his patrol looking at materials and designs for outdoor gear at outfitter stores. Eventually, Gihan and two fellow Scouts were so dissatisfied with the performance gear that was on the market that they set out to design their own.

An early prototype was a waterproof fleece vest. Through trial and error, Gihan came up with a vest design that met his needs. Materials selection for the vest's inner layer took him from plastic trash bags to DuPont™ Tyvek®, a lightweight waterproof and breathable barrier, popular in the construction industry. The inner layer is thermally laminated to two layers of Polartec® fleece. Gihan would use scraps of Tyvek from construction sites or shipping envelopes made of Tyvek when sewing his prototypes. **Remember, inventors are resourceful.**

Gihan Amarasiriwardena's vest being used out in the field

Today, Gihan continues to invent. He has interned with a sports engineering company to develop personalized racing shoes using *rapid prototyping* techniques. He continues to develop his own performance apparel and equipment line, Ascendure Mountain Technologies, for climbers and backpackers. "An engineer at heart, and with an appreciation for aesthetics, I love to develop new, innovative solutions that fuse technology and design." He graduated from MIT in 2011 with a degree in chemical and biological engineering.

Developing a classic vest meant that Gihan had to learn some new things, like how to sew. While his favorite tool is an MIG welder, the tool that he uses most often is a sewing machine. He learned how to weld and how to sew at his high school. For sewing, he took a class in clothing and textiles.



Inventor Gihan Amarasiriwardena, Eagle Scout

How did Gihan Amarasiriwardena decide to major in chemical engineering? "Scouting has had a huge role in guiding me toward my career goals. In fact, I first learned about chemical engineering through the Personal Management merit badge. One of our objectives was to learn about careers that may be of interest to us. I found that with chemical engineering, which is now my major, I could learn how to solve problems and combine my passion for innovation and business."

Feedback Is Key

It is important to get feedback on your idea while it is in development. By showing the intended user or potential customer models of your invention at the beginning of the design phase, their feedback will help you make improvements that will allow you to meet the needs of the user. Then, once you have a prototype, you will be able to seek feedback from users.

Writing down user feedback in your notebook is important. You may want to revisit what they have to say as you move forward with turning your idea into an invention.

A prototype is a functioning model of a design, concept, or invention.

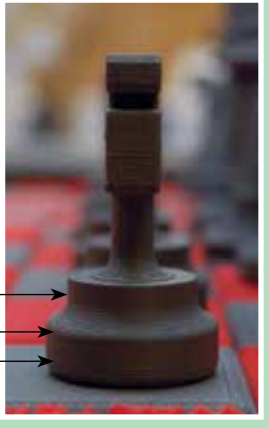
Models to Rapid Prototyping

Eventually, you will end up with a *prototype* that is very close to a finished invention. Inventors, engineers, and product designers use rapid prototyping to make the final design as quickly as possible. Prototypes may be scaled down in size but they are working models. This allows for a real-world check of the product's functionality before costly manufacturing.

Removing the smoke stack for a toy train from a 3D printer

A technology that helps inventors, engineers, and product designers with rapid prototyping is *3D printing*. A 3D printer will make a physical model from a 3D CAD design. A 3D printer works much like an inkjet printer. Instead of laying down just one layer of ink on a piece of paper, though, a 3D printer lays down thin layer upon thin layer of material to build up a physical prototype. Since 3D printing is now more affordable, high schools and libraries in your community may have printers that you can use.

Joshua and Jonathan Marino are playing chess. The board and the pieces were all printed on a 3D printer using ABS plastic. The plastic starts out in a cartridge and looks like grass trimmer line. No color is added; the material is ordered by color. The plastic is about 1/32" diameter when in the cartridge. The 3D printer feeds the ABS plastic into the head and melts it down to create a prototype with a 0.010" diameter bead of plastic.



Building the Prototype

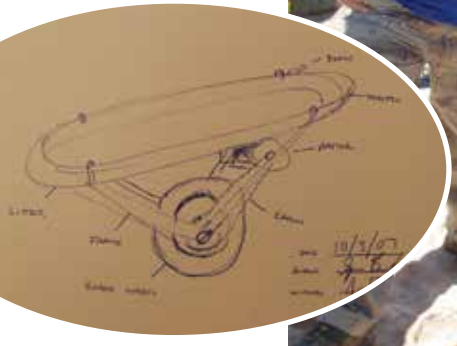
Taking an invention from an idea to a working prototype is a challenging project and can be a lot of work. You may want to consider putting together a team to jointly conceptualize, design, and build an invention. A team is similar to a patrol in Scouts BSA where **many hands make light work.**

Most inventions are developed by groups of people who all have strengths to bring to the team. Look at U.S. Patent 7,581,715 for the Powered Rope Ascender and Portable Rope Pulling Device. Besides Nathan Ball, there are three other inventors listed: Timothy Fofonoff, Bryan Schmid, and Daniel Walker.

Teenagers can form teams that focus on invention. A Lemelson-MIT InvenTeam from San Juan High School in Blanding, Utah, invented a power-assisted litter device for search and rescue. A volunteer search and rescue team member introduced the problem of backcountry rescues to a group of students in a pre-engineering class at the high school. After working together on a solution, the team defined its invention in this way:

> *PAL (Power-Assisted Litter) is a single-wheeled, motorized, portable, power-assist device. It is attachable to the majority of types and brands of current rescue litters and is to be used by rescue teams in a variety of terrains and rescue situations around the globe. An electric motor and a gas engine will be available for mine and backcountry rescues. PAL will reduce rescuer fatigue by 30 percent and improve rescue speed by 15 to 30 percent in both mine and backcountry settings, and will reduce the number of people needed by 50 percent for backcountry rescues.*

Lemelson-MIT InvenTeams are teams of students, teachers, and mentors who work together to identify real-world problems and then find inventive, technological solutions to these problems. Eight members of the InvenTeam from San Juan High School were Scouts.



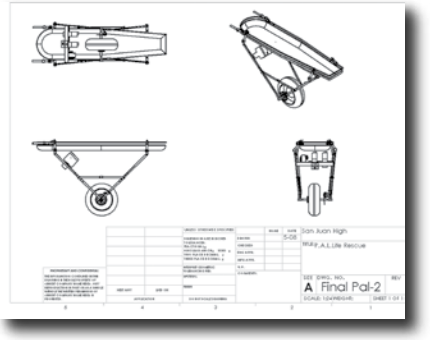
An early concept drawing of PAL from October 2007

The first thing the young inventors at San Juan High School did was investigate the problem by participating in a mock search and rescue expedition with members of their county's search and rescue team. They asked questions about the rescue process and tested current technologies. They learned from users the limitations and strengths of existing equipment.

Based on interviews with potential users—search and rescue team members—they began to conceptualize and list specifications, or basic things, that the PAL would have to do. This included the speed required, steepness of the hill it could climb, the weight of the person it could carry, how much it should weigh, and how durable it would be. Many times, the specifications changed, based on feedback from intended users.

The expedition was videotaped and viewed by team members. Everyone talked about their experiences and what they learned from the county search team members. The research was documented, specifications were written, and sketches were drawn. CAD models were designed.

In order to prove that the concept would work, a simple model was made combining the best ideas from the sketches. Building began once the model was created. A working prototype was built using thin-walled tubing called conduit for a frame; the front wheel was fashioned from an old tricycle; and a 12-volt battery was hooked to an electric motor with a simple chain drive. Field testing with users indicated necessary design changes.



A 2D drawing of second PAL prototype

Since building the initial prototype, three more have been designed, built, and field tested. More than 30 search and rescuers have tested one or more of the prototypes and provided useful feedback. Many things have changed since the original model, including the use of a smaller, lighter wheel; heavier-duty motors; more efficient batteries; hydraulic disk brakes; and a new belt drive. The electronic circuitry is being redesigned to give it variable-speed capability, and a future mine rescue version of PAL is being considered.

This 3D model of the second PAL prototype was created using SolidWorks 3D CAD software. High school inventors from the team and their teacher were awarded U.S. Patent 8,613,455 in 2013.

Scouts can earn merit badges that require tools. The Automotive Maintenance, Farm Mechanics, Home Repairs, Leatherwork, and Pioneering merit badges all require Scouts to use a variety of tools.

Building an Invention Requires Tools

You cannot build an invention or a working prototype without tools. You may need to find tools and learn how to use them outside the home environment. Perhaps your troop or shop class at school can be a resource. The drama club might have tools and a place to build sets. Or a local high school or school district may have vocational or technical programs offering after-school, evening, and summer enrichment courses in carpentry, machine technology, electronics, and robotics. Your merit badge counselor can help you locate resources.

Students at Brillion High School in Brillion, Wisconsin, are lucky enough to have a modern shop equipped to the hilt. This 10,000-square-foot facility includes a large four-plex processing lab for wood, metal, plastics, and composites, a state-of-the-art design room with computers, computer-numerical controlled machine tools, electronics, robotics equipment, and a 50-student lecture area. The center allows students to work on larger, more complex activities and on integrated projects with other disciplines, such as mathematics and science.

The Design Room of the Brillion High School Ariens Technology Center. Ariens Company Foundation funded the construction of the $1.5 million Technology and Engineering Education Center for students in Brillion, Wisconsin.

Safety Equipment

With a chest of basic tools, a bench, and a few power tools, you have a workshop. No shop is complete, however, without safety equipment, no matter how basic or how few one's tools may be.

- Safety glasses
- Hearing protection
- Fire extinguisher
- Goggles
- Dust mask
- Gloves

Safety With Tools

Scouts should always take appropriate safety precautions when using tools. Use eye and ear protection; have a fire extinguisher nearby; and do not work with tools without responsible adult supervision. You may have tools at home or have someone associated with your troop who can help you properly and safely learn the use of power tools.

For more information about safety with tools and building materials, see the *Composite Materials, Home Repairs,* and *Woodwork* merit badge pamphlets.

Tools for Building

As an inventor, you may eventually want to have your own tools. When purchasing tools, buy the best quality you can afford. Inexpensive screwdrivers are often made with soft metal edges that bend or break under stress. Besides being difficult to work with, they can be unsafe. Tool expert and professional engineer William Gurstelle suggests the following must-have tools and equipment.

- Hacksaw (for cutting something harder than wood)
- Handsaw (for cutting wood)
- Linear measuring gear (tape measure, protractor, combination square)
- Socket and wrench set (English and metric sockets, Allen wrenches)
- Pliers (standard, needle-nose, locking)
- Hammers (claw hammer and rubber mallet)
- Digital multimeter for electronics projects
- Screwdrivers (assortment of Phillips/cross-headed and plain/flat-headed)
- Scale
- Electric drill, cordless or corded
- Files and brushes (flat and round files, wire brushes)
- Cutters (scissors, wire cutter, utility knife)
- Mixing and volume-measuring equipment

HOWTOONS: The Possibilities Are Endless! **offers the "Anatomy of a Tool Bucket."**

Power Tools Beyond the Drill

When you have built a basic tool kit, you may decide to add a workbench and a few more useful power tools.

- Drill press
- Cut-off saw
- Grinder

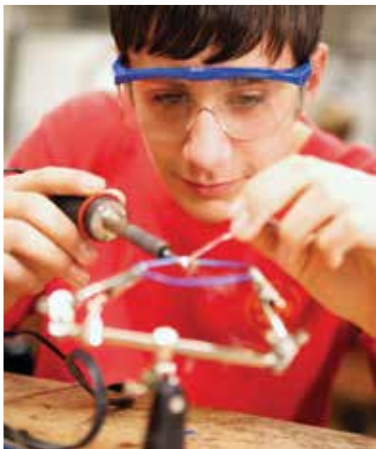
General Supplies

To complete your workshop, add a few general supplies to make your building easier. Remember that Kettner Griswold built his Trash to Treasure invention with very basic tools and hot glue.

- Tapes (masking, duct, clear adhesive)
- Adhesives (white glue, wood glue)
- Twine and ties
- Sandpaper for metal and wood of various grit
- Markers (pencils and permanent markers)

While this is a complete list of tools, you can get started with just a few tools of your own in a useful bucket. Check out local garage sales. Your bucket need not be new, but sturdy and large enough to carry your tools, supplies, and safety gear.

A soldering iron is a must for electronics projects



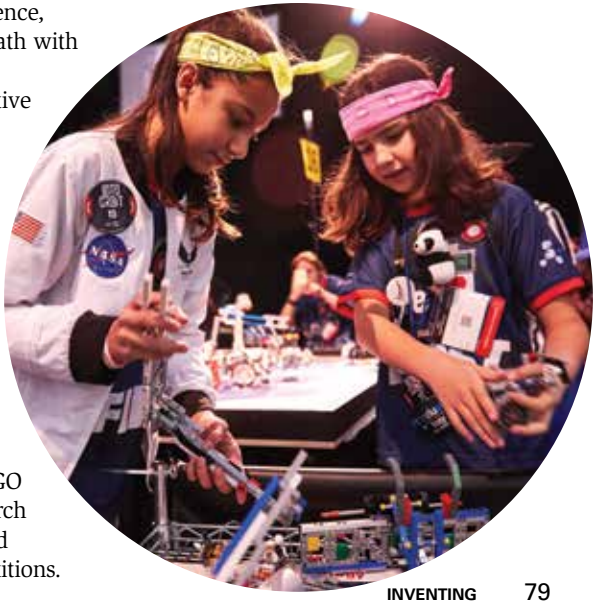
Special tools such as a soldering iron and magnifying lens can be surprisingly handy when you are building a prototype.

Community Resources for Inventors

Inventing need not be a "lone" process. Because we are often inspired by others, getting together with like-minded inventors can prove both enjoyable and useful as you work toward your inventing goals.

Inventing in Your Community

While you can experience the fun of inventing in your community as an independent inventor like Linda Mentz and her firefighter's gear invention, you might want to broaden your experience by becoming a member of a team, dedicated to addressing real-world problems with unique, technological solutions. There are many organized after-school opportunities to allow you to combine your knowledge of science, technology, engineering, and math with the ability to build something useful—a combination of inventive thinking and inventive doing. Following are a few excellent opportunities for young inventors.



FIRST

FIRST LEGO League® (FLL) is a team-based competition for youth. An annual theme-based challenge, focusing on a current technological or scientific situation, requires teams to build and program LEGO MINDSTORMS® robots. A research project that explores a real-world challenge is required for competitions.

Inventor Dean Kamen

In 2002, Dean Kamen was awarded the $500,000 Lemelson-MIT Prize for his inventions, particularly his medical technology breakthroughs such as the stair-climbing Independence™ IBOT™ Mobility System, which was revealed in 1999. The IBOT is a battery-powered wheelchair built from sensors, microprocessors, and gyroscopes that can climb stairs and stand upright on two wheels, empowering wheelchair users to see and move at eye level. Dean Kamen donated his Lemelson-MIT Prize money to his nonprofit organization, FIRST (which stands for "For Inspiration and Recognition of Science and Technology"). Many young people across the globe participate in robotics competitions organized by FIRST.

Kamen held more than 400 United States and foreign patents when he was inducted into the National Inventors Hall of Fame for his invention of the AutoSyringe®.

Dean Kamen rides his invention the Segway during the Lemelson-MIT Prize ceremony.

FIRST Tech Challenge (FTC) is for young people in grades 7 through 12. Small teams of up to 10 youths design, build, and program robots from reusable kits. Awards are given for the robot competition, community outreach, design, and other real-world accomplishments.

FIRST Robotics Competition (FRC) is for those in grades 9 through 12. In a highly competitive, sports-like atmosphere, teams of 25 or more build and program robots with time and resource limitations.

FIRST (For Inspiration and Recognition of Science and Technology) was founded by inventor Dean Kamen. With a passion for inventing, he has devoted his career to enhancing human capabilities through technology and innovation and exciting young people about science and engineering.

Destination ImagiNation®

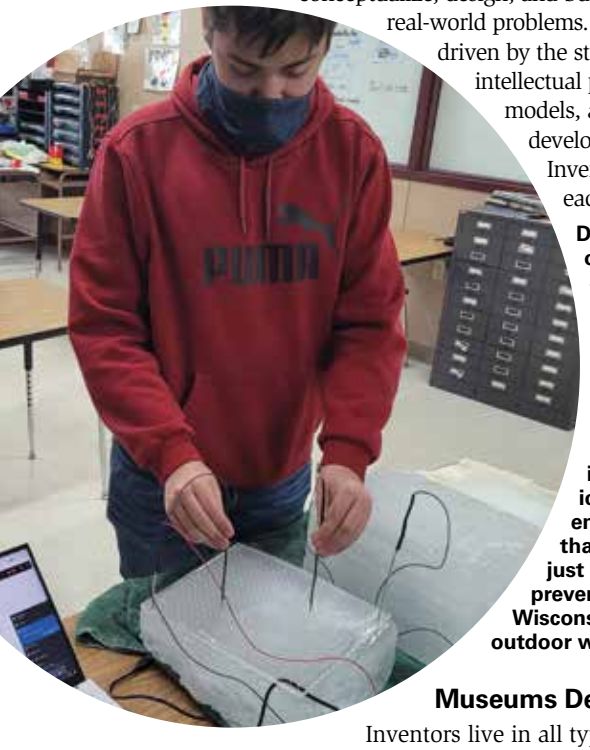
This creative problem-solving program is for participants from elementary school through college. The Destination ImagiNation (DI) program provides competitive team challenges and instant challenges each academic year. Competitions are held at the regional, state, and international levels.

eCYBERMISSION

eCYBERMISSION is a free, web-based science, math, and technology competition for students in grades 6 through 9, who compete for regional and national awards while working to solve problems in their communities. The U.S. Army sponsors eCYBERMISSION with awards for winners, regionally and nationally.

Lemelson-MIT InvenTeams®

The Lemelson-MIT InvenTeam initiative is the premier national grants initiative for inventive high school students. Teams of students and mentors receive grants of up to $10,000 each to conceptualize, design, and build technological solutions to real-world problems. Projects are collaborative efforts, driven by the students. InvenTeams research intellectual property issues, design parts, build models, and make modifications as they develop prototypes of their inventions. InvenTeams showcase their prototypes each June at MIT.



Dalton Oesterreich is a member of the Omro (Wisconsin) High School InvenTeam. He's a technical designer with a team working on a local problem: to keep people and vehicles from falling through thin ice on lakes in the winter. This InvenTeam is inventing an "Internet of Things" (IoT) device that will measure and report ice thickness from on top of the ice and from a distance. Dalton encourages others to look for ideas that will improve the way we live—just like his team's device, which can prevent accidents from happening in Wisconsin and in other places where outdoor winter enthusiasts live and play.

Museums Dedicated to Inventions

Inventors live in all types of communities. You can find them in urban, suburban, and rural areas. One way to find inventors who have been important to your community is through your local historical society. There may be a museum nearby that highlights technologies and inventors.

The **3M Birthplace Museum** is operated by the Lake County Historical Society in Two Harbors, Minnesota. The small museum is located in Two Harbors because the founders of 3M (Minnesota Mining and Manufacturing Company) found a mineral there in the early 1900s that they thought could be used for making sandpaper. The museum highlights the importance of research and development, product diversification, and growth of a company through innovation.

The **Cyrus McCormick Farm** is located at the Shenandoah Valley Agricultural Research and Extension Center in rural Steeles Tavern, Virginia. McCormick, the father of modern agriculture, invented the first successful mechanical reaper in 1831 when he was in his early 20s. The reaper was the beginning of a new industry of mechanical harvesting and made significant contributions to American prosperity.

McCormick's invention is on display at his ancestral home, Walnut Grove Farm (now called Cyrus McCormick Farm), in Steeles Tavern, Virginia.

Highlighting Invention at Museums

The **Bakken Library and Museum** in Minneapolis, Minnesota, collects artifacts related to the history of electricity and magnetism in medicine. Young inventors are supported through its Inventors Club.

The **Exploratorium** in San Francisco is a hands-on science center with a Tinkering Studio for the community.

The **Franklin Institute Science Museum** in Philadelphia, Pennsylvania, focuses on science and technology learning.

The **Henry Ford Museum of American Innovation** in Dearborn, Michigan, offers educational programs and exhibits based on the life of Henry Ford.

The **Jerome and Dorothy Lemelson Center for the Study of Invention and Innovation** is located in the Smithsonian Institution's National Museum of American History in Washington, D.C.

The 1903 *Wright Flyer*

From the Wright Flyer to the SR-71

The 1903 *Wright Flyer* and a Lockheed SR-71 *Blackbird* are both part of the Smithsonian Institution's collection of historically significant airplanes. The *Wright Flyer* was the first powered airplane that made a 12-second flight and traveled 120 feet. Sixty-one years later, the *Blackbird,* a high-speed, high-altitude reconnaissance airplane, made its first flight and continued in service for more than 20 years.

When one of the last *Blackbirds* was retired to the Smithsonian Institution in 1990, it flew from Los Angeles, California, to Washington, D.C., at a record-setting speed by crossing the United States in 1 hour, 4 minutes, and 20 seconds averaging 2,124 miles per hour. From the *Wright Flyer* to the *Blackbird,* air transportation has been made possible by skilled engineers, advances in materials science, and innumerable inventions.

The Lockheed SR-71 *Blackbird*

The **MIT Museum** in Cambridge, Massachusetts, offers insights to the foundations of science and technology.

The **Museum of Science** in Boston, Massachusetts, focuses on the importance of science for individuals and society.

The **Museum of Science and Industry** in Chicago, Illinois, offers hands-on interactive exhibits including one on inventing the future.

The **New York Hall of Science** in Queens, New York, focuses on science and technology with hands-on exhibits, events, and programs.

The **Oregon Museum of Science and Industry** in Portland, Oregon, focuses on science and technology.

The **Science Museum of Minnesota** in St. Paul has an Invention Playhouse to stimulate inventive thinking.

The **Smithsonian National Air and Space Museum** in Washington, D.C., houses airplanes and spacecraft with historical significance.

The **Tech Museum** in San Jose, California, focuses on science and technology.

The **Perot Museum of Nature and Science** in Dallas, Texas, offers hands-on, interactive ways to learn about science, math, engineering, and natural history.

Each museum listed has an extensive webpage that lists the exhibits and special programs available to Scouts and their families. Even if you cannot visit the museums in person, with your parent's permission, use your favorite search engine to find their websites. You can virtually explore concepts to build your knowledge of science and technology that will be useful to you as an inventor.

Inventing As a Career

Earning your Eagle Scout rank takes years of preparation just as being an accomplished athlete requires years of training. These accomplishments do not happen by accident. Nor does becoming an inventor happen by accident. Building your academic and technical foundation will greatly help you prepare for your journey of inventive thinking and doing.

Eureka!

The word "eureka" is commonly attributed to Archimedes, the Greek inventor and mathematician famous for Pi, when he realized an answer to a problem that seemed impossible to answer.

The king wanted Archimedes to determine if his new crown was made of pure gold—as specified—or of a cheaper alloy. Archimedes knew the mass of the crown. If he could determine the volume of the irregularly shaped crown, he could calculate the density by *dividing the mass by the volume.* Thus, he could compare the crown's density to that of pure gold. As the story goes, he discovered how to determine the volume when getting into a bath and displacing the water. This illustrative story about breakthrough thinking and a *Eureka!* moment has endured over time.

Inventors are leaders. They recognize problems in their world and seek solutions. They bring together resources—people, materials, money—to build appropriate solutions.

Preparing to be inventive begins with the toys you play with and the classes you take in school. Choosing classes that help you become more aware of your world will benefit you as an aspiring inventor. Math and science—including computer science—are important for working on your experimental and problem-solving skills. English helps you communicate your ideas to others. Art classes help you develop creativity and imagination.

Biologists can be inventors. So can chemists, engineers, auto technicians, nurses, and cross-country skiers.

In addition to your everyday school work, preparation comes from the activities you choose. Extracurricular activities that stretch you outside of your normal comfort zone are important for real-life problem-solving.

Consider joining a science club, math team, or robotics program. Being part of a drama club will help you develop confidence in presenting yourself and your good ideas. The key is to find something you love and throw yourself into it. When Isaac Newton was asked how he made so many great discoveries, he said, “By thinking about it night and day.” Thinking about math, science, and English will help you apply and integrate concepts in unique ways.

Be curious and observe the world around you. Never stop wondering **WHY** or asking **"What if . . ." questions.** Inventors are not trapped by what they know or don't know; they are flexible thinkers and can find their own answers. Inventors have certain traits that you may want to develop. They are persistent; they work through and learn from failures; they are comfortable working with complexity and ambiguity; and they are comfortable dealing with answers that aren't necessarily right or wrong.

Does a young person decide to become an inventor and then study to become one? Not usually. People develop inventive skills over time while they are also becoming profoundly **knowledgeable about their area of work or interest.** Biologists can be inventors. So can chemists, engineers, auto mechanics, nurses, and cross-country skiers, like John Fabel. All career fields can benefit from inventive thinking, particularly when the objective is to solve a real-world problem with a technological solution.

Inventions do not come easily. Thomas Edison, one of the greatest inventors of all time, recognized the value of hard work. In the end, great inventions happen because great inventors work hard. Doing your best in school and your other activities may be the best way to **BE PREPARED** to be inventive.

"Opportunity is missed by most people because it is dressed in overalls and looks like work."
—Thomas A. Edison, inventor

Glossary

2D. Two dimensions.

2D CAD. Software used to create two-dimensional models.

3D. Three dimensions.

3D CAD. Software used to create three-dimensional models.

3D printing. Technology for creating physical models (prototypes) by building up layers of material.

3-view drawing. A 2D drawing that provides three views of a model: Front, Top, and Right Side views.

algorithm. A predetermined set of instructions for solving a specific problem in a limited number of steps.

breadboard. A reusable thin plastic board for prototyping electronic circuits.

CAD. Computer-aided design.

computer-aided design. The use of computer software to create 3D models.

copyright. The exclusive right to the publication, production, or sale of the rights to a literary, dramatic, musical, or artistic work, or to the use of a commercial print or label, granted by law for a specified period of time to an author, composer, artist, distributor, etc.

crystal set. A primitive type of radio receiver with a crystal detector instead of an electron tube detector.

design. To plan and carry out, especially by artistic arrangement or in a skillful way.

design patent. Granted to the inventor of a new, original, and ornamental design for an article of manufacture.

division of labor. A sequential system of manufacture and assembly whereby each worker focuses on a specific task, which they repeat, instead of assembling the entire product.

engineering. The profession using science and technology to meet the needs of people; some specialties in engineering are civil, mechanical, electrical, chemical, aerospace, and biomedical.

entrepreneurship. The act of being an entrepreneur; an entrepreneur is someone who turns an idea into a new business venture.

eureka. Loosely translated as "I have found (it)"; an exclamation supposedly uttered by Archimedes when he discovered a way to determine the purity of gold by applying the principle of specific gravity.

intellectual property. Ideas and expressions of the human mind considered unique and original and to be worth money in the marketplace—and deserving of protection under the law. These include patents, trademarks, and copyrights.

innovation. The complex process of introducing new ideas into use and practice, primarily through entrepreneurship.

inventing. The process of coming up with and making—through independent investigating, experimenting, and thinking—something that is useful and that was not previously known or created.

invention. The product of the inventing process, which can encompass many things, ranging from devices and machines to chemical compounds and varieties of plants.

inventiveness. The form of creativity that results in an invention.

microchip. A semiconductor body in which an integrated circuit is formed.

monolithic integrated circuit. An electronic circuit containing many interconnected amplifying devices and circuit elements formed on a single body, or chip, of semiconductor material.

nanoparticles. Micro-miniature particles created by manipulating atoms and molecules as if they were parts of a machine.

parametric modeling. A system of CAD in which the parameters of a model are mathematically linked, enabling automated changes to all parameters associated with a single change.

patent. The right to exclude others from producing, selling, or realizing a profit from an invention or process for a specific number of years.

patent infringement. When someone tries to benefit commercially from a patented item or uses it without licensing it from the patent owner.

plant patent. Granted to someone who invents or develops, and asexually reproduces, any distinct or new variety of plant.

prototype. A working model of a design, concept, or invention.

rapid prototyping. Any technology that enables the production, creation, or manufacture of a physical model quickly and inexpensively.

routine problem-solving. Developing solutions to problems that have specific and predictable results.

seminal inventions. Inventions of such sizable impact that they change the way people live. The monolithic integrated circuit is an example of a seminal invention.

trademark. A symbol, design, word, brand name, letter, slogan, etc., that is used by a manufacturer or dealer to distinguish a product or products from those of competitors.

unique. The one and only; single; sole; having no like or equal; unparalleled; highly unusual; extraordinary; rare; etc.

utility patent. Granted to someone who invents or discovers a new and useful process, machine, article of manufacture, or composition of matter, or any new and useful improvement thereof—the most common type of patent.

Inventing Resources

Scouting Literature

American Business, American Labor, Architecture and Landscape Architecture, Composite Materials, Digital Technology, Drafting, Electronics, Engineering, Entrepreneurship, Game Design, Home Repairs, Metalwork, Model Design and Building, Programming, Robotics, Textiles, and *Woodwork* merit badge pamphlets

With your parent or guardian's permission, visit Scouting America's official retail website, **scoutshop.org**, for a complete listing of all merit badge pamphlets and other helpful Scouting materials and supplies.

Books

Anderson, Maxine. *Amazing Leonardo da Vinci Inventions You Can Build Yourself*. Nomad Press, 2006.

Boy Scouts of America. *Boy Scouts Handbook, The First Edition, 1911*, reprint. Dover Publications, 2005.

Brown, David E. *Inventing Modern America: From the Microwave to the Mouse*. MIT Press, 2002.

Brown, Travis. *Popular Patents America's First Inventions From the Airplane to the Zipper*. The Scarecrow Press, 2000.

Carson, Mary Kay. *The Wright Brothers for Kids*. Chicago Review Press, 2003.

Griffith, Saul, Nick Dragotta, and Joost Bonsen. *Howtoons: The Possibilities are Endless.* HarperCollins Publishers, 2007.

Macaulay, David, and Neil Ardley. *The New Way Things Work*. Houghton Mifflin Company, 1998.

Robinson, James. *Inventions*. Kingfisher, 2006.

Sobel, Dava, and William J. H. Andrewes. *The Illustrated Longitude*. Walker and Company, 1998.

Woodford, Chris, James Flint, Ben Morgan, Clint Witchalls, and Luke Collins. *Cool Stuff and How It Works.* DK Publishing Inc., 2005.

Periodicals

Make
makezine.com

Inventors Digest
inventorsdigest.com

Organizations and Websites

CreativeFuture
creativefuture.org

Design Squad
pbskids.org/designsquad

FreePatentsOnline
freepatentsonline.com

Howtoons
howtoons.com
This do-it-yourself comic website with tools of mass construction includes fun projects.

Lemelson-MIT Program Massachusetts Institute of Technology
lemelson.mit.edu/
The program recognizes outstanding inventors, encourages sustainable new solutions to real-world problems, and enables and inspires young people to pursue creative lives and careers through invention. The program is funded by the Lemelson Foundation and administered by the Massachusetts Institute of Technology.

OpenCourseWare
ocw.mit.edu/index.htm
A special section, "Highlights for High School," features materials useful for students and their teachers.

SolidWorks®
solidworks.com
Free trial software is available.

U.S. Patent and Trademark Office
uspto.gov

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LEMELSON-MIT

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Sara DeSalvo, courtesy—pages 68 and 69 *(Scouts, chess piece)*

George Doyle—page 24 *(car)*

The vision for this merit badge and much of the content for the *Inventing* merit badge pamphlet was provided by Scouts from across the country, many of whom are young inventors. In addition to Scouts, many people from university laboratories, high schools, museums, and corporations gave freely of their time and resources to make this merit badge a reality because they believe in the inventive spirit.

Nick Dragotta—pages 28–29 *(bridge illustration)* and 52

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Eric Long and Mark Avino, National Air and Space Museum, Smithsonian Institution (SI 2000-9346), courtesy—page 84 *(SR-71 Blackbird)*

Linda Mentz, courtesy—page 64

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U.S. Library of Congress/Wikipedia.org—page 20 *(Cyrus McCormick)*

U.S. Patent and Trademark Office—page 39 *(Scout badge patent)*

uspto.gov—page 35

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Brian Payne—page 24 *(cyclists)*

MERIT BADGE LIBRARY

Though intended as an aid to youth in Scouts BSA and qualified Venturers and Sea Scouts in meeting merit badge requirements, Scouting America's merit badge pamphlets are of general interest and are made available by many schools and public libraries.

Always check scouting.org for the latest merit badge requirements. If a Scout has already started working on a merit badge when new requirements for that merit badge are introduced, *they may continue to use the same pamphlet to earn the badge and fulfill the requirements therein.* In other words, the Scout need not start over again with the revised requirements.

American Business
American Cultures
American Heritage
American Indian Culture
American Labor
Animal Science
Animation
Archaeology
Archery
Architecture
Art
Astronomy
Athletics
Automotive Maintenance
Aviation
Backpacking
Basketry
Bird Study
Bugling
Camping
Canoeing
Chemistry
Chess
Citizenship in the Community
Citizenship in the Nation
Citizenship in Society
Citizenship in the World
Climbing
Coin Collecting
Collections
Communication
Composite Materials
Cooking
Crime Prevention
Cycling
Dentistry
Digital Technology
Disabilities Awareness
Dog Care
Drafting
Electricity
Electronics
Emergency Preparedness
Energy
Engineering
Entrepreneurship
Environmental Science
Exploration
Family Life
Farm Mechanics
Fingerprinting
Fire Safety
First Aid
Fish & Wildlife Management
Fishing
Fly-Fishing
Forestry
Game Design
Gardening
Genealogy
Geocaching
Geology
Golf
Graphic Arts
Health Care Professions
Hiking
Home Repairs
Horsemanship
Insect Study
Inventing
Journalism
Kayaking
Landscape Architecture
Law
Leatherwork
Lifesaving
Mammal Study
Metalwork
Mining in Society
Model Design and Building
Motorboating
Moviemaking
Multisport
Music
Nature
Nuclear Science
Oceanography
Orienteering
Painting
Personal Fitness
Personal Management
Pets
Photography
Pioneering
Plant Science
Plumbing
Pottery
Programming
Public Health
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Scuba Diving
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Search & Rescue
Shotgun Shooting
Signs, Signals, Codes
Skating
Small-Boat Sailing
Snow Sports
Soil & Water Conservation
Space Exploration
Sports
Stamp Collecting
Surveying
Sustainability
Swimming
Textile
Theater
Traffic Safety
Truck Transportation
Veterinary Medicine
Water Sports
Weather
Welding
Whitewater
Wilderness Survival
Wood Carving
Woodwork

ON THE ROAD TO HIGH ADVENTURE

Discovery is at the heart of Scouting. We believe every adventure helps us uncover a little more about ourselves. Scouting builds the foundations for courage, resilience, and character, preparing youth for a lifetime of leadership. The path is yours to forge. Who knows what you'll discover?

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