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# American Land Surveying, an Essential History: The Profession of Frontiersmen, Philosophers & Presidents

*Instructor: Patrick C. Garner, PLS*

**2020**


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5272 Meadow Estates Drive
Fairfax, VA 22030-6658
Phone: 703-988-0088
www.PDHonline.com

# American Land Surveying, an Essential History: The Profession of Frontiersmen, Philosophers & Presidents

***Patrick C. Garner, P.L.S.***

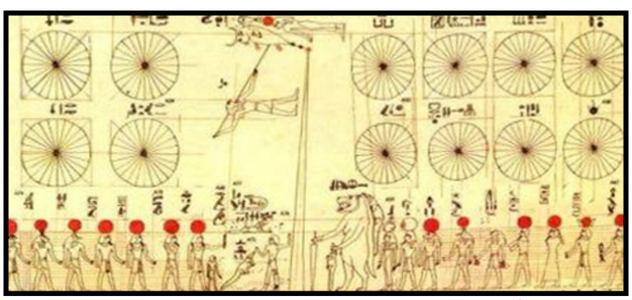
"To understand the present we must know the past. Surveyors therefore study the past, not to tie themselves to it, but to benefit from the experiences of others."

--John G. McEntyre, *Land Survey Systems* (1978)

## Ancient Surveys

No history of American surveying can be complete without a brief acknowledgement of the crucial role that surveying has played since the most ancient beginnings of civilization. Wherever humankind has recognized local or individual ownership of land, the physical establishment of boundaries—essentially lines defining use or divisions of ownership—has been crucial. Throughout history boundaries have defined wealth, fixed taxable areas, divided farms, marked lines of use between families and established the width and length of public roadways.

The establishment of boundaries goes back to at least 3,000 B.C. The civilization of ancient Egypt was oriented around the Nile River, which was subject to annual floods. Constant retracement surveys between farms were required. Inscribed stones were used to demarcate lines and corners. Surveying was not confined to Egypt. Archeologists have found evidence of Babylonian boundary surveys assumed to date to at least 2,500 B.C.



Numerous examples abound in tombs and pyramids of Egyptian surveying and astronomical arts.

From about 150 B.C., boundary preservation was so important to the Romans that they worshipped a god called Terminus, who they believed protected boundary markers (*terminus* was the Latin word for a boundary marker). Sacrifices, usually of a pig or a lamb, sanctified each boundary stone, and landowners celebrated an annual festival called Terminalia in February. The Roman poet Ovid wrote,

> O Terminus, whether you are a stone or a stump buried in the field, you have been deified from days gone by… you set bounds between peoples and cities and vast kingdoms; without you every field would be a place of dispute. You court no favor, and are bribed by no gold; you guard the lands entrusted to you in good faith.

Monuments were of the greatest public importance, and accordingly, throughout ancient times numerous countries had royal commandments (and often lengthy curses) against destroying or moving such markers.

Romans called the art of determining and defining land ownership and boundaries cadastral surveying. The phrase—still commonly used throughout the world—is derived from Latin (*capitastrum*), and is first found in writings going back 2,000 years. Cadastral refers to the registration of the value, area and ownership of land. Landowners were required to physically mark their bounds. For the purposes of avoiding disputes (and far more importantly, to produce reliable taxes), regional governments throughout the empire recorded all properties in a local cadastre. For owners, registering land on the cadastre was an assurance of good title.

Understanding measurements was essential to all expanding civilizations. Ancient surveyors were often as much architects and astronomers as they were surveyors. Basic geometry is the underlying principle of ancient surveying, and was used in the construction of increasingly large public buildings, aqueducts, roadways, monuments and bridges. The word *geometry* is derived from the Greek, *geo* = earth, *metria* = measure), A contemporary term for surveying—geomatics—is derived from the identical origin.

Knowledge of the rules of geometry (and of early trigonometry) was often considered precious and secret—and was passed down among the elite and learned. In ancient times, such learning was an esoteric art, as much associated with philosophy and religion as it was with pure mathematics. Far from being a mere technical exercise, the application of geometry was a source of privilege, authority and mastery.

The rules and dictates of accurate measurements were applied to the construction of the ancient world's most famous monuments. The Egyptians were extraordinary practitioners of mathematics, tying it in with observational astronomy. As early as 3,500 B.C., the pyramids in ancient Egypt were precisely aligned with polar north, and from that astronomical foundation, were built to startling precision. Similar feats of construction took place in Babylonia, Susa and numerous associated cities.

In Athens, between 450 and 250 B.C., the Greeks assembled public buildings that even today amaze experts with their mastery of geometry. The world-famous Parthenon was built to high precision, a clear declaration that its creators were more than well schooled in the Egyptian mathematical arts. Centuries later the Romans expanded their empire using these same tools of measurement, building not just larger public and private areas of assembly, but vast aqueducts to carry drinking water to cities and roadways that connected key trading partners in the shortest distances. These successes were all dependent on a masterful application of measurement, using both horizontal and vertical calculations in ways never before seen.

The need to accurately define boundaries remained a constant for millenniums. As civilizations grew and expanded, specializations occurred. A polymath such as Leonardo da Vinci, who was an engineer/painter/surveyor/sculptor, would rarely be found in succeeding centuries. Men mastered far narrower skills.

Some of this specialization was inevitable as professions became more complex. Engineering and surveying began to be practiced together as a distinct and learned trade. As Europeans settled in the New World, these specializations were imported without change into the pre-American colonies. Accordingly, colonial surveyors relied entirely on English surveying texts from the 17th century. American surveying texts, written by Americans and published in America, did not appear until the early 19th century.

## Colonial Surveys

Before America broke off from its English yoke in the late 1770s, the early colonies were predominately small, locally oriented communities, often separated from each other by many miles. The scattered homestead communities became in time densely clustered around town centers. Defining the separation of residential parcels from each other and marking the boundaries of "wood lots" became critical for all the usual reasons, not the least being to maintain harmony between neighbors. In post-glacial areas of the country where surface stones were common, particularly in New England, stonewalls were built to clear farm fields and create permanent boundaries. But not all lines were so obvious.

In 1641 towns in the Massachusetts Bay Colony were ordered to mark their boundaries within the year. Although areas varied, the average size of early towns was six square miles. Massachusetts towns assigned certain individuals to perambulate, or walk, the boundaries every three years to avoid disputes. That tradition continues by law into our time, and almost all town lines in Massachusetts are marked by large granite posts.

Throughout the original 13 colonies, irregular (that is, non-grid) property lines prevailed. These newly defined lines were rarely the result of any preconceived plan. In addition, random settlement formation tended to create difficult boundary identifications. Monumentation throughout the colonies was inconsistent, and general understandings between neighbors, rather than permanent markers, frequently defined lines.

Grants to settlers were based on vague descriptions, constituting a poor foundation for any retracement work. This pattern of irregular and unplanned development predominated for over a century throughout the eastern seacoast, from Maine to Georgia.

Property descriptions in the original colonies were by the *metes and bounds method*. This traditional method, long established in Europe, involved making descriptive calls along each property line for direction and distance. Therefore, a line description might read, "Thence proceeding northerly N 22° 15' E for a distance of 6 chains."

Better descriptions identified corners markers such as a "white oak tree" or "blazed ash" or an iron post, so that the description would read, "Thence proceeding northerly N 22° 15' E for a distance of 6 chains to a white oak tree." But such descriptions were the exception. Too often corners were not identified. In the early settlements there was almost always an understanding between seller and buyer, who were frequently relatives or acquaintances, about a property's size and location.

As surveyors who have worked from these early deeds know too well, hurried or careless descriptions often excluded the compass bearings, so a line call would instead read, "Thence proceeding northerly for a distance of 6 chains." Without calling out compass directions and without identifying physical, indisputable corner markers, the early surveyors, clerks, lawyers and village scriveners who crafted these conveyances doomed future generations to endless line disputes.

As populations grew the demand for land surveyors grew in tandem. In the earliest years there were few full time surveyors, except in the largest cities along the eastern seacoast. Most practitioners were local men who worked part-time at surveying, drawn to the work through their love of the outdoors and mathematics. No one licensed these individuals—they succeeded, if they practiced for more than a few years, through their reputations.

These men were strictly boundary survey experts—with the exception of the occasional request for them to determine whether water from a "spring-head" could be conveyed to another location. Surveyors used an early level called a water-level for such work. Otherwise, the incorporation of combined surveying and civil engineering skills was still a century or more away.

Towns were agrarian-based, without the need for complex or large-scale infrastructures—such complexity would come in time as the country developed. Civil engineering, if it were even considered, was conducted by eye, using practical applications and tried and true techniques. On the other hand, even in the 17th century, the boundary between squabbling neighbors was never a casual matter.

Surveyors were locally based, providing their services within several towns, and at most, within a narrow region. Inevitably, localized survey practices arose, with certain regions favoring generally agreed upon ways of marking lines and corners. Monuments might be granite bounds in one region, iron stakes in another or wood posts in yet another. Although the English foot prevailed in the original colonies, in certain areas the actual length of a foot varied. Hence, local knowledge of conditions and common practices became critical. In the same way that citizens spoke in different accents in different regions, survey methodology frequently varied from one town to another.

Surveyors learned their skills by apprenticing. No formal schools existed to provide surveying studies—and none were needed. Not only were accuracy expectations low, the mathematical skills necessary to survey were part of normal schooling at the time. In addition to studying Latin, reading from classical books and practicing writing skills, every student was exposed to years of geometry and trigonometry. Euclid's *Elements of Geometry* was a common, and often required, text, providing sufficient mathematical grounding for a student to understand triangles, squares, parallelograms, irregular figures and polygons.

In the field, the practical survey application of angles and distances was passed from father to son, or from surveyor-to-surveyor. Rarely did 17$^{th}$ and 18$^{th}$ century surveying require complex skills. Property values were low and public expectations of accuracy were proportional.

As an example of presumptions of accuracy, John Love in *Geodaesia* (a 1682 surveying text described below) refers to a table of sines and tangents he provides and writes,

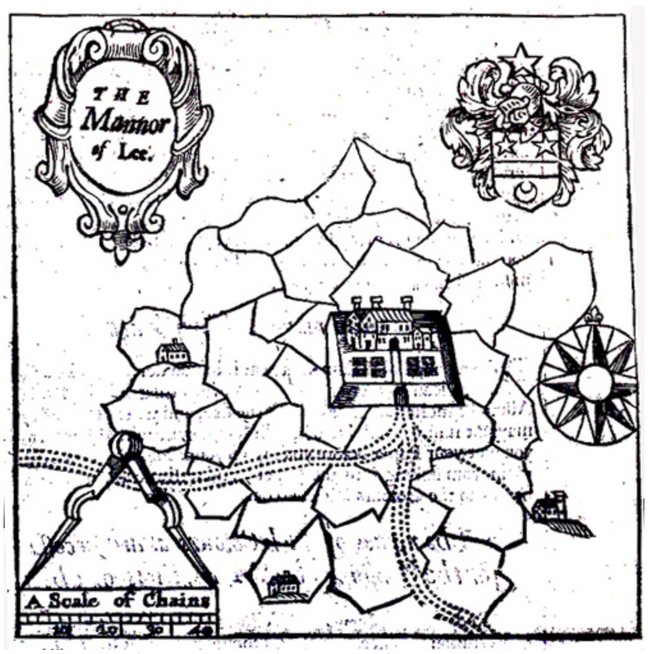
> I… make a Table but to every Fifth Minute, that being nigh high enough in all sense and reason for the Surveyor's Use; for there is no Man, with the best instrument that was ever yet made, can take an Angle in the field higher, if so high, as to Five Minutes.

Of course typical modern instruments today are capable of reading angles to a precision 200 to 300 times greater.

## Early Surveying Texts

Although a number of English books were available to the early surveyor, two remain as key references for surveyors specializing in retracement work. The earliest is from 1653-57. *The Compleat Surveyor, Containing the whole Art of Surveying of Land*, by William Leybourn, a London-based practitioner, is remarkable for its breadth of subject matter. In his book Leybourn promises "to make a man in short time become exquisitely proficient in the Geometrical part of Surveying."

Leybourn was a mathematician and practicing surveyor in England. He was a member of the Royal Society and his text was intended to impress his contemporaries, as well as to be a comprehensive treatise. He covered definitions, theorems and survey problems. Instruments and tools discussed were the theodolite, the circumferentor, the plain table, and the cross, chains, protractors, scales and field books. He provided tables of sines and logarithms, as well as working formulas to solve right-handed and oblique triangles. The drafting of plans was discussed at length—a section near the end of the book is entitled, "To draw a perfect draught of a whole Manor, and to furnish it with all necessary varieties."



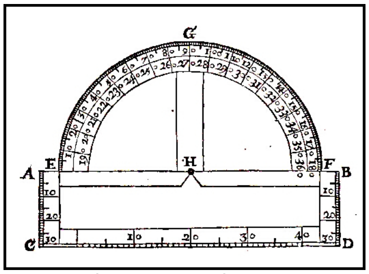
An example of a suggested survey plan from Leybourn's book.

Twenty-five years later, in 1682 John Love, another English gentleman, published a competing text, *Geodaesia, or The Art of Surveying and Measuring of Land, Made Easie*. *Geodaesia* was another common text used by colonial surveyors, who were no doubt drawn to the promise in its title to make surveying "easie." Although Love's book, too, was published in London, it was targeted partially to American surveyors. One of the book's many subtitles reads,

> How to Lay-out New Lands in America, or elsewhere: And how to make a Perfect Map of a River's Mouth or Harbour; with several other Things never yet Published in our Language.

With the exception of a chapter on "Laying Out New Lands," Love follows Leybourn's order and subjects almost exactly. In his preface, Love writes memorably,

> What would be more ridiculous, than for me to Praise an Art that all Mankind know they cannot live without? It is near hand as ancient as the World: For how could Men set down to Plant, without knowing some Distinction and Bounds of their Land?


Etching of a protractor from John Love's book.

These two English books sat on most surveyors' shelves for the first 150 years of American surveying. In time surveying manuals were written and published in America. Connecticut-based Abel Flint printed the *Treatise on Geometry, Trigonometry and Rectangular Surveying* in 1804, and Gibson published the widely used *Theory and Practice of Surveying* in 1833 in Philadelphia. These texts provided expanded trigonometric tables and the standard formulas used by practicing surveyors throughout the country. They also addressed new surveying challenges that arose with the advent of railroads.

In 1855, William Mitchell Gillespie, a surveying and civil engineering professor at Union College in New York, published *A Treatise on Land-Surveying*. Although he purported in his introduction to have reduced the art of surveying down to five essentials, in fact Gillespie's manual is similar in content and advice to both Leybourn and Love's earlier texts, and to Gibson and Flint's more recent books. The transit is introduced in Gillespie's text, but otherwise the basic principles of geometry and trigonometry, calculation of areas and drafting remain unchanged.

In 20th century America, more and more surveying books would be published, many emphasizing legal issues and public land survey procedures. An iconic example is the 1912 edition of *Boundaries and Landmarks* by Mulford, a pocket guide still in print today. Other examples include the 1922 edition of *Clark on Surveying and Boundaries*, the 1930 edition of Skelton's *Boundaries and Adjacent Properties* and the small text from 1942 by Charles Breed titled simply, *Surveying*. The last half of the 20th century saw numerous American books published on this same subject. All echoed the fundamental surveying principles found in the earliest English books that had been imported into the colonies two centuries before.

## Frontiersmen, Presidents & Philosophers

Surveying in early America attracted an incongruous assortment of sturdy men—outdoorsmen, highly educated military men, estate owners, adventurers and philosophers. Bold personalities were attracted to the work and famous men worked outdoors. George Washington, Thomas Jefferson, Daniel Boone, Abraham Lincoln and Henry David Thoreau all worked as land surveyors, often serving crucial roles in their local communities as the creators of boundaries, easements and lease holdings. Today's

American surveyors often look for their original footprints, which surveyors for generations afterward have retraced.

**Daniel Boone**

Boone is one of the most famous of the early pioneer adventurers. Living in eastern America in the late 17th and early 18th century, Boone acquired fame as an outdoorsman long before he settled down to any conventional occupation. Late in his life he performed surveys of questionable integrity. John Mack Faragher, in *Daniel Boone: The Life and Legend of an American Pioneer,* writes that Boone was

> sworn in as a deputy surveyor of Fayette County [Kentucky], adding this to his assortment of titles that included county sheriff and lieutenant colonel of militia.

But Boone soon encountered trouble. His newly sprung profession as a titled surveyor was declared by a local court to be a front for a get rich quick scheme.

Apparently, using his title as surveyor, Boone claimed ownership to numerous tracts by recording surveys. He soon gave the appearance of having acquired large land holdings in Kentucky for his clients, who were wealthy investors from large eastern cities. As the courts later saw it, his scheme was to sell the investors stock in his company and acquire shares himself. To entice these men to purchase stock, Boone marketed his name and guaranteed to secure all parcels with good title.

Faragher notes that regardless of Boone's great fame, his survey qualifications "amounted to little more than political connections and the ability to read, write, and cipher." Following litigation (as the actual land owners discovered the fraud), the courts found that Boone could not provide title to the lands he claimed. He lost his own shares and found himself deeply in debt to the men to whom he had given guarantees. He was ruined in short order, and by 1803 was forced to give up his official titles. He soon withdrew from surveying.

**George Washington**

Born in Virginia in 1732, Washington remains America's most famous surveyor. At age 15, after flirting with the idea of a career in the British Royal Navy, he instead began studying geometry and surveying, using a set of surveyor's instruments from a storehouse at his father's farm. Among the earliest maps attributed to Washington are sample surveys included in his so-called "School Boy Copy Books," housed in the George Washington Papers in the Library of Congress. The schoolbooks include lessons in geometry and practice land surveys Washington prepared at the age of 16.

Surveyors were often among the best-educated Virginians and were in an excellent position—as they found clouded and unclear land titles—to purchase land for themselves, which Washington did over time. It was not unusual for surveyors to acquire large estates from the many opportunities they had to patent land in their own names. Additionally, their intimate knowledge of the land and their official capacity as representatives of large land holders made their participation essential to major land companies such as the Loyal Land Company of Virginia, the Ohio Company and others.

In July 1749, at the young age of 17, Washington secured an appointment as county surveyor for the newly created frontier county of Culpeper, where he served until November 1750. He was then in active practice in the Alexandria area for several years, later creating what are now considered propaganda maps during the French and Indian War in the mid-1750s. (He also served as lieutenant colonel of the newly formed Virginia Regiment.)

Later, before his involvement as general and prime military strategist for the colonies during the Revolution (and before his political interests were cemented), he continued to survey the rural lands of his native state into the 1760s. As Edward Redmond, Senior Reference Librarian, Geography and Map Division of the Library of Congress writes,

> Given Washington's experience organizing the western frontiers of Virginia as a public surveyor, the impact of the map and report he made of his expedition to the Ohio Valley in 1754, and his lifelong involvement with the making and using of maps, it is altogether fitting that he should have been celebrated as America's premier surveyor.

**Thomas Jefferson**

Some 23 years after Washington became a county surveyor, Jefferson followed a similar path, securing a commission as surveyor in 1772 of Albemarle County, Virginia. Jefferson was then 29. He was following his father, a man who had worked as a surveyor and cartographer for most of his adult life. Yet Jefferson only worked in this public capacity for a year. His later surveying was almost entirely for his own uses. As the Jefferson Encyclopedia notes,

> Surveying for the younger Jefferson was primarily a tool for imposing order on his farms. Dozens of plats survive today from projects he undertook to rationalize and describe his lands in Bedford and Albemarle counties. In 1793, for example, Jefferson surveyed his fields in order to revise their boundaries in accordance with new schemes for crop rotation.

Unlike Washington, who worked as a classic land surveyor, Jefferson was more fascinated by the techniques of surveying than in providing a public service. The Encyclopedia notes,

> Jefferson owned at least two surveying compasses. In 1778, he acquired a more sophisticated instrument for the task, a theodolite produced by Jesse Ramsden. The Ramsden theodolite could turn angles in both the horizontal and vertical planes, which extended its utility beyond surveying. In 1815, for example, he employed it to determine the elevation of the Peaks of Otter in the Blue Ridge Mountains.

In 1804, as President Jefferson created the Corps of Discovery, which led to the Lewis and Clark Expedition to explore and map the continent. Jefferson's influence on American land surveying is discussed further in the section on public land surveys.

Jefferson's famous Ramsden theodolite.

**Abraham Lincoln**

Struggling financially as postmaster of New Salem, Illinois, Lincoln in the fall of 1833 had friends persuade the Surveyor of Sangamon County to "depute" him to work as a fellow surveyor in an adjoining portion of his county. Lincoln, only in his mid-20s and destined to become President in 1860, was so appointed. He knew nothing about surveying at that date.

According to Carl Sandburg, a great American poet and Lincoln biographer, Lincoln "procured a compass and chain, studied Flint, and Gibson a little, and went at it. This procured bread and kept soul and body together."

It is worth quoting Sandburg at length. He writes of Lincoln,

> He surveyed the towns of Petersburg, Bath, New Boston, Albany, Huron, and others. He surveyed roads, school sections, and pieces of farmland from four-acre plots to 160-acre farms. His surveys became known for care and accuracy and he was called on to settle boundary disputes. In Petersburg, however, he laid out one street crooked. Running it straight and regular, it would have put the house of Jemima Elmore and her family into the street. Lincoln knew her to be working a small farm with her children and she was the widow of Private Travice Elmore, honorable in service in Lincoln's company in the Black Hawk War.

Lincoln worked as a surveyor in New Salem for only a short time, and ran for office while so employed. Apparently his contacts with the public as a surveyor did him no harm. On the contrary, he used the opportunity to introduce himself as honorable and steadfast. Within four years of beginning his surveying career, he moved to Springfield as a newly elected legislator.


Lincoln using a surveyor's compass.

Although as a surveyor he was self-taught—like almost all surveyors of his time—Lincoln quickly became known for his accuracy. Lincoln's surveying compass, which is now owned by the State of Illinois and is on display in a visitor's center at New Salem, had the usual support pole and a sighting device, and was capable of measuring angles within a few minutes of arc. Lincoln's distances were recorded to the nearest link (7.92 inches), horizontal accuracy typical of the time.

**Henry David Thoreau**

Thoreau, a Harvard graduate and author from Concord, Massachusetts, who made Walden Pond a focal point of an emerging environmental consciousness in America, worked for many years as a land surveyor. By the early 1850s, Thoreau's facility as a land surveyor was widely admired and he supplemented his income by surveying for more than a decade. Although Thoreau worked simultaneously at his family's pencil factory, published two books in his lifetime and often gave lectures, these other pursuits were never profitable enough for him to give up his surveying practice.

For Thoreau, surveying was intellectually interesting and provided a steady income. But it also provided an opportunity to pursue his obsession: writing increasingly detailed natural history observations about the 26 square mile township in his journal, a two-million word document he kept for 24-years. "Surveying," he wrote in the Journal, "seems a noble employment which brings you within hearing of the birds."

In 1847, Thoreau described his life for the members of his Harvard class this way:

> I am a School master—a Private Tutor, a Surveyor—a Gardener, a Farmer—a Painter, I mean a House Painter, a Carpenter, a Mason, a Day-Laborer, a Pencil-Maker, a Glass-paper Maker, a Writer, and sometimes a Poetaster.

Thoreau's first survey was in 1846 of the now-famous Walden Pond, conducted while he was living there and writing *Walden*. He began to offer property surveys professionally in 1849, and for the following 12 years, he completed more than 100 surveys around the Concord area. The largest tract he surveyed was a 260+ acre compound on the banks of the Raritan River in Perth Amboy, New Jersey—and as it turned out, his largest survey was the only out-of-state survey he ever conducted.

Henry David Thoreau, 1856.

At the time, the owner of the site, a Mr. Marcus Spring, sought Thoreau out to do the survey. The invitation came on a recommendation from Thoreau’s friend, Bronson Alcott, father of Louisa May (author of *Little Women*). Alcott became acquainted with Marcus Spring through Nathaniel Hawthorne’s sister-in-law, who was then teaching locally.

By this point Thoreau was more than capable of handling a survey of this size. He had been surveying professionally for seven years, and according to the plans on file at the Concord Free Public Library, had done at least 88 surveys by that time. It may have been Thoreau’s skill as a surveyor that swayed Marcus Spring, but it was more than just surveying that was on Spring’s mind.

Thoreau’s reputation as a lecturer offered Spring the opportunity for Thoreau to present a series of Sunday evening lectures to local residents. Always interested in travel, Thoreau accepted the offer, completed his survey, conducted lectures and returned to Concord in November 1856. He is known to have continued surveying at least until 1860, the same year that Lincoln became President.

## Public Land Survey System, 1785 to 1815

Until 1785 all surveying in America was by the metes and bounds method. As previously discussed, property lines were commonly irregular and created without forethought or master planning. They sometimes followed a seller's whim, or traversed natural features, or meandered down old Indian trails. Not until the rectangular system was implemented on public lands was a broad, systematic grid imposed to create future township lines based on magnetic, directional meridians.

McEntyre notes in *Land Survey Systems* that in 1784, Thomas Jefferson was appointed chairman of a committee instructed to create a systemized plan for subdivision of public lands. This was deemed critical so that land disposal—which was to go on for more than 100 years—would be orderly and logical. As we have seen, Jefferson had become a county surveyor in Virginia 12 years earlier. With his background and growing fascination with large scale planning, he was ideal to chair such a committee. McEntyre notes that the committee's work was punctuated by vociferous discussion and debate, although it is not at all certain that Jefferson himself originated the concept of the rectangular system.

Regardless, the committee promulgated an ordinance that was ratified in May of 1785 by the Continental Congress. The "Ordinance for Ascertaining the Mode of Locating and Disposing of Lands in the Western Territory" made a number of key stipulations:

- The geographer of the United States was to direct the surveyors.
- Land would be divided into 6 square mile townships by lines running due north and south, with other lines crossing them at right angles.
- The geographer was to designate the townships and fractional parts thereof by numbers running progressively south to north.
- Ranges were to be numbered westward.
- Townships were to be subdivided into 36 lots of 1-mile square each (an area of 640 acres per lot).
- External township boundaries were to be marked every mile.
- A purchaser would receive a written certificate, or deed, providing title. The land was to be surveyed before being sold.

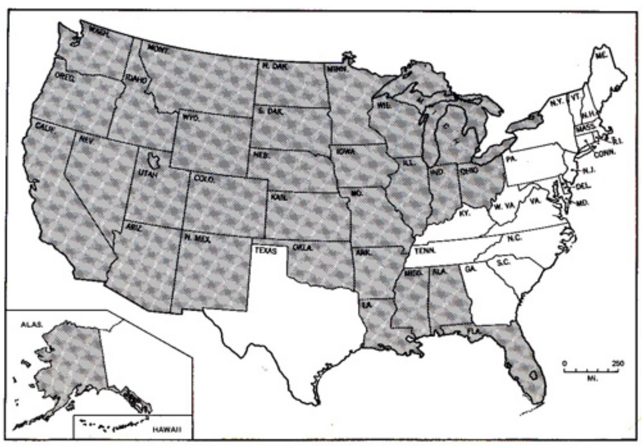
Survey instructions in the Ordinance were vague. Procedures, distance and angle measuring equipment to be used were not specified. Nor were accuracy standards specified. The ordinance was silent about methods to attenuate errors. Still, the act required each surveyor and chainman to take an oath to faithfully discharge his duties. At its most specific the act specified that

> …lines shall be measured with a chain… Surveyors shall pay the utmost attention to the variation of the magnetic needle…

In subsequent years, the act was amended or expanded almost 12 times. Key amendments were

- The Ordinance of 1788
- The Act of May 18, 1796
- Acts of March 1 and May 10, 1800
- The Act of March 3, 1803
- The Act of March 26, 1804
- The Act of February 11, 1805
- The Act of March 3, 1811
- The Act of April 25, 1812, and a further set of instructions established by Congress in 1814.

Increasingly specific instructions for surveyors were issued between 1805 and 1815. The acts applied to 29 of the states, as well as the Territory of Alaska. The acts applied to the retracement of old surveys, as well as new surveys as settlement expanded westward into new territory.



States utilizing the Public Land System (from McEntyre, *Land Survey Systems*).

The 30 years following the promulgation of Jefferson's initial ordinance was a period of great activity, clarification and specificity. Rules were implemented, shortcomings were identified and field experiences were analyzed. Revisions in 1788 required that plats identify physical features—mines, mills, watercourses, mountains, swamps and other key features.

A major event occurred when Edward Tiffin, Surveyor-General of the United States, issued comprehensive survey instructions in 1815. These instructions at last specified procedures, levels of accuracy (for instance, requiring sections to close), chaining directions, compass construction (the Rittenhouse style was required—see more about Rittenhouse in the section about early instruments), needle "regulation" and monumentation construction. There were general instructions for deputies, including extremely specific procedures for keeping field notes. Astronomic observations were required to periodically check accuracy.

We know now from many decades of retracement surveys that these constant amendments and detailed instructions did not totally eliminate carelessness or negligence by public land surveyors. Original surveyors (considered someone who *creates* a property line and corner in a particular location, not someone who retraces a line) did not always follow controlling instructions. For example, surveys that were not actually run were recorded as completed in field books. Required monuments were not always set. At times the quality of land or its resources was minimized or exaggerated. As one writer has noted (Madson, *Fading Footsteps*),

> The hazards and hardships encountered were factors that induced the original surveyor to speed the completion of his contract to perform the survey. The money that he was to receive after the survey was completed and his notes and plat were accepted was a double incentive to hurry up the work.

Undoubtedly, conditions were frequently harsh, wolves and marauding Indians were a constant threat, medical help was not available and diets were simple and monotonous. Transportation was by horse and donkey. We can perhaps excuse some of the errors of this wilderness surveying. Still —regardless of their oaths of office—for many of these rough-and-tumble surveyors, the temptation to cut corners proved too great.

## Public Land Survey System, 1816 to 1854

Modifications to Tiffin's Instructions were issued between 1816 and 1854. Modifying acts were passed in

- May of 1824
- May of 1830
- April of 1832
- July of 1836
- September of 1850
- with other minor revisions passed through 1854.

Generally these subsequent acts did not refer to survey procedures. Yet it should be noted that numerous modifications or supplements to Tiffin's Instructions were issued to Deputy Surveyors for individual states.

In 1831 "specimen field notes" were issued for Mississippi, followed in 1832 by specific Instructions for the same state. In 1833 Instructions were issued for the Territory of Arkansas. Similar publications for various states or territories were made almost yearly through 1856, when Instructions for Deputy Surveyors were issued for the states of Illinois and Missouri.

## Public Land Survey System, 1855 to 1901

In 1855 the first revised and comprehensive set of survey-related instructions was issued by the federal government. It was titled *Instructions to the Surveyors General of the Public Lands of the United States for Those Surveying Districts Established in and Since the Year 1850 Containing Also, a Manual of Instructions to Regulate the Field Operations of Deputy Surveyors*. Although it was largely a revision of the 1851 instructions for Oregon, it was more detailed and stood as the first general public lands manual. Subsequent manuals were published in 1871 (an exact copy of the 1855 manual), 1881, 1890, 1894, 1902 and 1930. Further manuals were published after WW II.

McEntyre notes that "each manual adopted more refined procedures to absorb convergence." He further notes that "specifications concerning accuracy became more specific and explicit in this period." In general, the manuals became more detailed regarding survey procedures, and addressed numerous special cases, often encountered on a state-by-state basis.

## Public Land Survey System, 1902 to 1973+

During this later period four manuals were published. Releases were dated 1902, 1930, 1947 and 1973. Several of these were simply minor revisions to previous editions, while several constituted major restructuring of the manual format.

- The 1902 manual was essentially identical to the 1894 manual, except that it provided further guidance for the subdivision of a township into sections.

- The 1930 manual constituted a major restructuring of the manual format. The rectangular system was not changed, but the discussion regarding implementation was revised considerably (while still reflecting the basic instructions of 1894 and 1902). As with the 1902 manual, most survey-related changes involved the subdivision of a township into sections.

- The 1947 manual made no major technical changes, instead providing additional historic information and technical data regarding initial points and principal meridians. As with the previous two manuals, in this version most survey-related changes involved the subdivision of a township into sections.

- The 1973 manual was called *Manual of Instructions for the Survey of the Public Lands of the United States, 1973*, and was further identified as Technical Bulletin 6 of the Bureau of Land Management (BLM). The manual constituted a

> reorganization and clarification of previous manuals. The basic system did not differ appreciably from the 1947 manual. Technically, more sophisticated survey techniques were discussed, including use of electronic telemetry, triangulation and photogrammetry. These new techniques allowed more accurate distance and angle measurements.

At least through early 2009, the 1973 manual remains the official publication guiding surveys of public land. The Public Land Survey System (PLSS) is now 225-years old. It stands as an increasingly refined way of subdividing and describing land in the United States. As noted, the PLSS methodology does not apply to metes and bounds surveys within the original 13 colonies. All remaining lands in the public domain are subject to subdivision by this rectangular system of surveys, which is currently regulated by the U.S. Department of the Interior, BLM.

## The Use of Boundary Monuments During Three Centuries of American Surveying

Methods of marking property corners varied dramatically throughout the early colonies, as they did later in America as a nation. Boundary marking was inconsistent, and general agreements between abutters (rather than the use of permanent markers) frequently defined lines. In New England, lines were often defined by stonewalls that separated farm fields and wood lots—but even this practice was inconsistent. Marked trees were frequently used—but their permanence lasted only as long as the tree. Fences were not maintained. Original wood and iron stakes rotted. Stone bounds were stolen, plowed over or forgotten.

For as long as surveying has been conducted in America, the creation (and maintenance) of boundary corners has been problematic. This difficulty is an ancient one. Remember Terminus, the god of boundaries, whom the Romans worshipped? Nevertheless, the recovery of original corners is one of the more satisfying tasks of every boundary surveyor. To be called upon to simultaneously be a detective, mathematician and archeologist when confronting seemingly inscrutable challenges is a unique reward.

Because monuments have played a key role in original surveys and retracement surveys, a look at types of monuments in a historical context is important. Reference in this section is made to the 1912 edition of *Boundaries and Landmarks* by Mulford, the 1922 edition of *Clark on Surveying and Boundaries*, the 1930 edition of Skelton's *Boundaries and Adjacent Properties*, the 1977 edition of McEntyre's *Land Survey Systems*, Madson's 1980 edition of *Fading Footsteps*, the fifth edition (2006) of Robillard, Wilson and Brown's *Evidence and Procedures for Boundary Location* and Wilson's *Forensic Procedures for Boundary & Title Investigations* (2008)—all books that should be on every surveyor's shelf.

An early monument, Scandinavia.

*Man-made Monuments*

The American search for permanent boundary corners certainly goes back to pre-Revolutionary times. The surveyor's ingenuity has been endless, although relatively permanent solutions have appeared only in the last decades. Historically, building corners, sidewalk intersections, gun barrels, plowshares, buggy and car axles, wagon hubs, and copper, lead and iron pipes have all been used. Iron bars, pry bars, iron rebar, nails, spikes, bricks and assorted stones, concrete monuments and wood stakes have also been used… and this list is by no means comprehensive.

The recent introduction of alloy metal markers, often embedded with magnets and "flarable" ends (to discourage their removal) has brought the ancient quest for permanence closer to fruition. Many of these newer markers are projected to last for centuries. In addition, manufacturers now furnish break-off monuments as well as sectional rods that are driven deeply into the ground to the point of refusal.

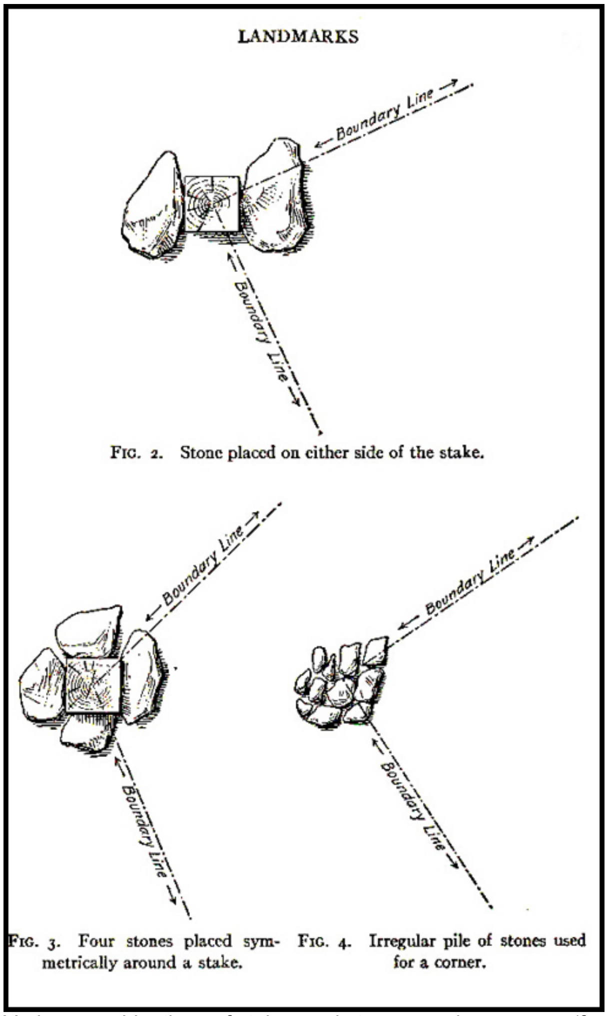
None of these options prevents a determined person from removing a corner, but they are far superior to wood stakes, iron rebar or pipes, and even concrete bounds. Recovery of corners has also been simplified as more and more new and old monuments are GPS-located to high accuracy.

Of note, PLSS Instruction Manuals designate specific corner types. Although this course will not describe each corner type in detail, some were remarkable for their time. The 1855 manual set forth the most detailed corner instructions to that date. Corners were to be wood posts, beveled at the top to deflect rain, to be set 24-inches into the ground and the same height above the surface. Sides of the stakes were to be notched, with township, section corners and quarter section posts to be notched differently. In accompanying diagrams the installed post is shown mounded in a rounded, earthen pyramid.

The same manual specified instances that required stone monuments. Such stones were to be inserted to a minimum depth of 7 to 8-inches, and were specified as being a minimum size of 3 x 12 x 14-inches, or 504 cubic inches. Stone edges were to be set north and south on north and south lines, and east and west on east and west lines.

An example of a Public Land Survey monument.

Although no one is sure, the oldest monuments used in the colonies were likely fieldstones and wood stakes. Rectangular fieldstones, often chiseled with identifying marks, were commonly used in England and other European countries. The colonists continued their use. Surveyors in many parts of America used combinations of stakes and stones (see illustration).




Various combinations of stakes and stones used as corners (from Mulford, *Boundaries and Landmarks*).

Where stonewalls marked property lines, it was generally accepted that property lines roughly split the middle of the walls. Particularly in New England, drill holes were often set in walls at points of turn. These holes were precise and permanent points—as long as stonewalls were not rebuilt, destroyed, or modified during seasonal maintenance, which are all common occurrences.

Wood stakes were also frequently used, particularly in regions where stones were uncommon. Some surveyors used pine stakes. Others, conscious of the longevity of their markers, used oak, yellow locust and ash or other hard woods that were locally available. Depending on varying soil conditions, stakes made from softer wood—pine, for instance—would often rot quickly, whereas stakes made from harder wood sometimes lasted for many decades.

Property lines were at times, and in some regions, marked by ditches or what were called *balks*, which are low walls of earth built along a line. These were often purposely constructed and, in the case of ditches, served as a practical manner of marking a line while simultaneously draining wetlands. At times, a balk would form as a result of plow activity. Repeated plowing would loosen earth beside a property line, generally lowering the elevation of the field and leaving the unaltered property line slightly higher.

Fences and walls often served the double purpose of marking lines while enclosing cattle or other farm animals. Fieldstone walls have been previously discussed. Other walls may be built from blocks of stone or concrete, wood, wire (chain link, barbed or multiple strand), sheet metal, running wood rails and other materials. When fences mark a line, a corner fence post may act as both a structural reinforcement and as a property marker. These posts may be constructed of metal, wood or even concrete.

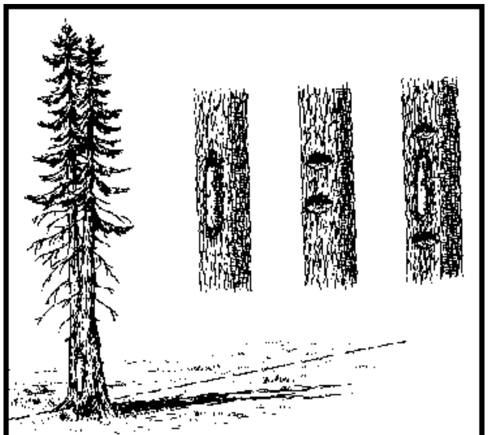
Of course, fences are subject to the vagrancy of time, and have the same vulnerabilities as trees. Their occasional advantage is that they may be replaced, in place, when their useful life ends. A fence line or wall may persist over generations, as succeeding owners maintain the line. Stonewalls, however constructed, are considered more permanent, although particularly in northern climates they frequently require periodic maintenance. In highly urbanized areas where houses and buildings may share common walls, so-called *party walls* may represent property lines, either down the middle of the walls, or down either side, depending on age.

Note that fences may not always reflect actual property lines. They may be random fences, or may have been intended to be on a property line but are not. On the other hand, fences may precisely occupy property lines. Some fences may indicate adverse possession, or may simply be built in the wrong location. It is outside the range of this course to discuss the many legal nuances that determine these issues. An interested surveyor should refer to some of the books noted throughout this course for appropriate information.

*Natural Monuments*

*Trees* were frequently used as either property corners, corner accessories (sometimes known as bearing or reference trees) or line markers. They functioned well for this purpose, as they were highly visible and not subject to loss in winter conditions. They handily survived during periods of prolonged flooding (in some southern regions, cypress trees, deep in swamps and frequently inundated, have survived for generations as corner markers).

As corners, trees were sometimes marked with blazes, hacks and at times carved with identifying numbers and letters. In some regions large stones were jammed into the base of a corner tree, or multiple stones were used to surround a corner tree to further memorialize the corner.



Examples of various tree blazes.

Trees were also commonly used as property line indicators (the PLSS referred to them as "line trees," "sight trees" or "station trees"). There was great variation regionally in marking patterns—sometimes trees were given a single blaze, sometimes a double or triple blaze. At times line trees were blazed on opposite sides, particularly when a tree was precisely on a property line—although this, too, was a regional peculiarity. As Mulford notes, "In general, blaze marks are to be regarded as suggestive and collaborative rather than determinative." A surveyor had to be familiar with these local variations, as well as be familiar with the sometimes-idiosyncratic tree marks used by competitors.

Whereas ancient fieldstones may persist as corner markers through today, trees have short lifetimes, are subject to disease, lightening strikes, fire, mischief, ice storms and loggers. Some survive for generations, others last less than a decade. Their historic use was prevalent—largely because trees were often readily available on lands being surveyed—but they lacked permanence and precision. Rare is the surveyor who has not been frustrated by a 100-year old legal description calling for a "white oak tree" corner or a "tree marked with an X."

Upon walking a property thus described, the contemporary surveyor too frequently observes open fields without a single tree, or simply cannot find a white oak tree in the vicinity that is less than 30-years old. Further, most deeds (and most old plats) failed to note the tree diameter, age or any other defining characteristic. In short, trees remained ideal line and corner markers as long as neighbors agreed to their accuracy, as long as they were remembered and as long as they stood.

Aside from the common use of trees, historically American surveyors—particularly on original surveys—have used convenient natural objects as corners. Madson in *Fading Footsteps* notes the historic use of lake edges, streams (banks or centerlines), rock outcrops, large boulders, ledges, ridge tops, abrupt changes in topography or other naturally formed lines or objects. All of these were used at various times as natural monuments.

Madson's list could be expanded to include springs, river forks or intersections, inlet and outlet points on ponds, old gulleys and any other naturally found object that at the time of the original survey seemed a convenient or appropriate marker. The American surveyor's ingenuity, when use of such natural features was expedient or opportune, was endless.

It should not be forgotten that to original surveyors the great advantage to using natural objects was their apparent permanence and visibility. Unlike iron pipes or other artificial markers, rock outcrops, massive boulders and springs tend to remain in place. On the other hand, rivers and streams that appear as permanent features are, in fact, dynamic, and frequently shift location during large flood events. Lake and pond edges expand and retreat, their variability driven by seasonal ground water, flooding, withdrawals and impoundments.

A surveyor, using any historic natural monuments, must be able to verify, as he would any monument, that the object itself has not shifted in location. Madson notes another advantage to these monuments—such markers, if verifiable, "take precedence over artificial monuments."

As noted in the discussion regarding fences, it is outside the range of this course to discuss the many legal nuances that drive the use of natural monuments. An interested surveyor should refer to the books noted throughout this course for appropriate information, as well as the most recent edition of *Brown's Boundary Control and Legal Principles* by Robillard and Wilson.

## Early Survey Instruments

> There are but two material things towards the measuring of a piece of Land to be done in the field; the one is to measure the Lines and the other to take the quality of an Angle included by these Lines; for which there are almost as many Instruments as there are Surveyors.
> --John Love, *Geodaesia* (1687)

As noted, Leybourn and Love described early survey instruments at length. The most common instruments used were the theodolite, the circumferentor, the plain table and, occasionally, the cross. Each will be briefly discussed.

*Theodolites*

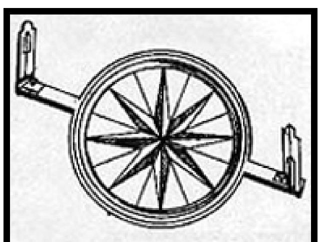
Theodolites were (and still are) relatively sophisticated instruments used to obtain either vertical or horizontal angle measurements. The word theodolite first appears in the surveying textbook *A Geometric Practice named Pantometria* (1571) by Leonard Digges. As theodolites became more common, those that turned only horizontal angles were called half-theodolites or plain theodolites.

In actual practice, most boundary surveyors used the plain theodolite because the simpler version cost less. In addition to being able to measure angles, most theodolites came with a magnetic needle. (However, both Leybourn and Love recommend against use of "the Needle," for reasons understood by any practicing surveyor. Magnetic needles can be influenced by nearby iron deposits and other attractions that may vary in intensity from location to location, leading to a variety of errors reading direction.)

Theodolites have been in use for more than 400 years. As noted, one of Thomas Jefferson's prized survey instruments was an elaborately made theodolite. When the author began surveying in the 1970s, boundary surveys were conducted using Swiss-made Wild T-2s and T-16s, the gold standard in theodolites at the time. In fact, today's total stations are simply highly sophisticated electronic theodolites.

*Circumferentors*

The circumferentor is commonly known today as a surveyor's compass, and was used to measure horizontal angles. The theodolite largely superseded it, as it is able to turn far more accurate angles.



Example of a 17th century Circumferentor.

The circumferentor consisted of a brass circle attached to a horizontal base. On the circle was a compass divided into 360 degrees. (Note that some later European compasses were divided into grads, divisions of 400 degrees.) A meridian line denoting north and south divided the base. Similar lines for east west were etched perpendicular to the north-south line.

On the circumference of the circle was a brass ring, which, when fitted with glass made a sealed enclosure for the magnetic needle. The needle itself was suspended in the center of the circle. A sight mounted above the circle allowed the circumferentor to be aimed down a line. The instrument was commonly mounted on a one-legged staff, with a rotating ball-and-socket joint.


Contemporary reproduction of an early surveyor's compass.

Early circumferentors were made in England, France, Italy and Holland. By the early 1800s, European surveyors preferred theodolites to circumferentors. However, the circumferentor was commonly used in America into the middle of the 20th century.

Of note, David Rittenhouse, colonial America's foremost instrument maker, made many notable instruments for American surveyors, including the surveyor's compass. He lived from 1732 to 1796. Rittenhouse was an astronomer, surveyor, clockmaker and a maker of mathematical and surveying instruments. He was a friend of Benjamin Franklin, and is considered one of the leading American scientists of his time.

Rittenhouse knew and made instruments for George Washington, Andrew Ellicott, Thomas Jefferson and others.

*The Plain Table*
Today spelled *plane* table (and sometimes referred to as a traverse table), the early plain table was at its simplest a drawing board mounted on a tripod with a rotating sight/ruler called an *alidade*. An alidade is a device that allows one to sight a distant object and use the line of sight to perform a specific task.

A sheet of drawing paper was mounted to the table. Using the plain table, observed points on the ground were immediately plotted in their correct relative positions. In the late 19th and 20th century it was commonly used to complete the compilation of maps from aerial photographs, particularly where the ground was obscured. No numerical values were secured, so its use was graphical only. It was also a key tool of the USGS in completing early topographic Quadrangle maps.

As a measure of the accuracy of surveys in the 17th century, the plain table was often the sole instrument used to compile features of a survey. Leybourn in his 1657 text states that the plain table is

> the most absolute Instrument of any other for a Surveyor to use, in that it performeth whatsoever may be done either by the Theodolite, Circumferentor, or any other Instrument, with the same ease and exactness.

Regardless of Leybourn's enthusiasm, use of plane tables today is extremely rare in any type of professional surveying.

*The Cross*
The cross was a less commonly used device to ensure the measurement of right angles. Quoting directly from Leybourn,

> This instrument is of good use in small enclosures of many sides… It is only two Rulers of Wood, in length about 14 Inches, crossing one another in the midst at right angles, and having at each end of both the Rulers back-sights, which serves only to set out right angles in the field itself.

Of interest, John Love's text a quarter century later makes no mention of what Leybourn considered an essential surveying tool. Later American texts similarly make no mention of the device.

*The Chain*
The instruments mentioned so far are all angle-turning or measuring devices. Distances were measured using a *chain*, a device that was relied upon in Europe and America for well over 350 years. Composed of metal links, the chain came in two varieties in England—the foot chain and the decimal chain. The foot chain was denominated in feet, or 12-inches, while decimal chains were denominated in units of 10, a precursor to today's metric system. The chains were conventionally 66-feet long.

Chains were further subdivided into what were called *perches* or *poles*, each 16.5-feet in length, a quarter of a chain's length. Over time poles became more commonly known as *rods* in this country. Leybourn called the chain that became the American standard, "Master Gunther's chain"—a chain of 66-feet divided into 100 links.

In the colonies it became known as Gunther's chain. In fact, Leybourn called Gunther's chain "the best of any other." John Love, discussing the logic of Gunther's chain, notes that twelve inches make one foot, three feet one yard, five and a half yards a pole, four poles a chain and eighty Gunther chains "one Mile."

Love goes on to advise the aspiring surveyor,

> Take care that they which carry the Chain, deviate not from a straight Line; which you may do by standing at your Instrument, and looking through the Sights: If you see them between you and the Mark observed, they are in a straight Line, otherwise not.

## Later Survey Instruments

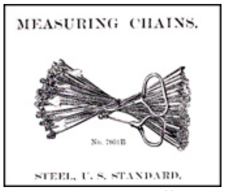
*The Transit*
The transit is a specialized type of theodolite developed in the early 19th century. It replaced a similar, but less accurate instrument known as a railroad compass. It features a telescope that can "flop over" (or "transit the scope"), thus allowing easy back-sighting and doubling of angles for error reduction (many late 20th century theodolites came with the same features). Some transit instruments were capable of reading angles directly to thirty arc-seconds. In the mid 20th century, transits came to be recognized as simple, inexpensive theodolites with less precision, and lacking features such as scale magnification.


A 19th century Buff & Buff transit.

*The Chain*
The Gunther chain remained the standard measuring tool for many years, although by the 19th century in America it came with variations. Typically made of iron, steel or brass, chains were commonly available in lengths of 50, 66 and 100-feet. By the early 20th century, chains could be purchased in 10 and 20-meter lengths.

Although these options were still available to American surveyors as late as 1960, by the 1930s linked chains were gradually being replaced with steel or nickel steel ¼-inch wide tapes. The new tapes were furnished in 50, 100, 150 and 200-foot lengths, and in 30 and 50-meter variations. Eventually, steel tapes would replace the venerable Gunther chain; chains became a curiosity displayed in a surveyor's front office.

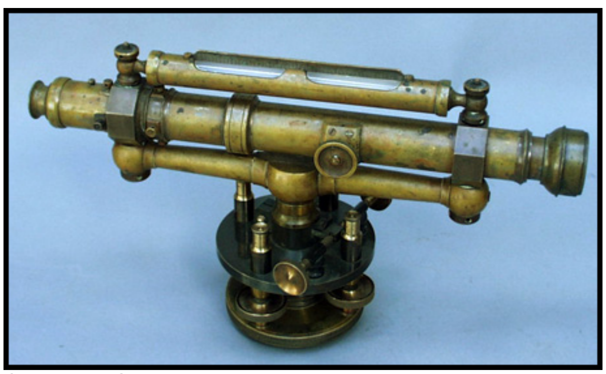
Of note, Rittenhouse, the maker of Jefferson's prized theodolite, also manufactured what became known as the "Pennsylvania Chain." Available by at least 1800, it was furnished in a length of 40 links (33 feet long) and was made of brass. Brass is a superior material to iron for this purpose, as it is less subject to wear. (One of the downsides of any chain is that it becomes longer with wear, decreasing accuracy.)



A survey chain offered by K&E in 1944.

*The Level*
Levels *were* commonly available in a variety of styles, with brand names like *Engineer's, Precise, Gurley, Wye, Spirit and Dumpy.* These are all variations of instruments designed solely to determine elevations. The better levels measured vertical change more accurately than transits or theodolites.

Mechanical levels all consist of a telescope with a magnifying lens (typically 10 to 32X magnification) to which is mounted one to two bubble levels. Although all levels rotate on their mount, they do not turn recordable angles. Many came supplied with stadia hairs on the sighting device, which allowed an instrument person to simultaneously record elevations, as well as estimate horizontal distance to the point measured.


Circa 1870 Gurley level.

By the 1990s manufacturers were offering electronic, digital levels that were quicker and more accurate than mechanical versions. Often the data from these new levels can be transferred electronically to handheld data collectors for later use in a computer.

Many specialized instruments were developed, particularly in the 20th century. It is beyond the scope of this course to describe in detail the many devices used. In brief, they include total stations, robotic devices, reflective measuring tools, advanced clinometers, variations on the surveyor's compass, use of tacheometry to measure distances, specialized instruments and attachments used for field astronomy, and the development of specialized theodolites and telescopes for use in underground mining.

A 1975 Wild T-16 theodolite.

Other electronic and aerial measurement advances have been made in the surveying field since the early 1990s. These include satellite-derived GPS, LiDAR and instrument robotics, all of which promise to revolutionize the surveying field.

In the future, the 1980s and 1990s will be considered a brief transitional period during which land surveyors shifted from mechanical measuring devices used with little change over thousands of years, to electronic and digital measuring instruments that record more accurately, quickly and with previously unimaginable precision. Mechanical theodolites—once the pinnacle of the instrument maker's art—will become, like chains, mere curiosities and displays in a surveyor's office.

## Scoundrels & Opportunists: the Public Demand for Protection

Laws applied to surveyors working on government lands, but there were no rules that guided work for private entities. Throughout much of America's early history, land was cheap and survey measurements were held to a low standard. Disputes and scandals caused by sloppy land surveying arose as land became more expensive. Because of repeated "paper surveys" that purported to reflect physical surveys but were in fact manufactured from whole cloth, public demand for regulation became common.

Although the majority of surveyors took pride in their work, the actions of a few led to public outrage, political backlash and eventually to demands for licensure. In the 1890s surveying as a profession was first regulated in California, largely driven by a demand for more accurate mining surveys. In 1907 the first engineering regulations were instituted. But these changes neither took place overnight, nor happened nationwide. Change was slow and incremental.

By the early 1920s land was being marketed with increasing ingenuity by developers on both coasts. Land values soared, particularly in exotic locations with lakes, beaches and ocean views. A speculative land boom occurred in Florida. In the ensuing frenzy, some surveyors did not follow ethical practices. Subdivisions were drawn up representing upland lots that were really swamp or under water, even at low tide.

Such fraud was possible as long as buyers remained out of state. When owners began to travel south to view their new vacation holdings, the discovery that they had been sold a small rectangle of mangrove swamps led to swift litigation.

In 1925 Florida passed the Plat Act (Ch 177 FS) to protect the public from the numerous bad plats on record. Before this, subdivision plats could be merely sketched on paper, without regard to quality, accuracy and physical monumentation. The new Act required that each plat be drawn to specific standards and have standardized content. In 1927 the land boom in Florida ended and values crashed. Historians of the period conclude that the crash was the result of fraud, wildly inflated prices and an ill-timed hurricane that swept through southern Florida, destroying millions of dollars in newly-erected properties.

The land crash proved to be a remarkable precursor to the 1929 Wall Street crash. Regardless of the 1925 Plat Act, many fraudulent surveys were discovered and damages to the public were extensive. The perpetrators of the surveying fraud did their profession little good. Public trust in land surveyors, particularly in areas impacted by the land crash, vanished.

In many ways, this unfortunate crash was the beginning of the end of unregulated surveying. Decades would pass before all states required that surveyors be licensed, but eventually licensure became mandatory.

## Licensure Requirements: From Unlicensed Surveyors to Registered Land Surveyor

*1930s to 1960s*

In Florida in 1933, surveying became regulated by a new practice act (Ch 472). The act was distinct from the engineer's act (Ch 471) instituted in the same year. Florida—and many other states that followed—recognized legislatively that surveyors work in a distinctly different profession than civil engineers.

Surveyors were suddenly restricted by statute to focus on the aspects of land boundaries, and not on the wider practice of engineering design. However, the engineer's act retained a provision recognizing "engineering surveys," which it does to this day. The act allows engineers to perform topographical and layout surveys in support of an engineering project. (Surveyors, on the other hand, could no longer design pipes, culverts and roads. Surveyors, if not outmaneuvered by civil engineers through this legislation, at least found the scope of services they could offer minimized.)

Regardless, in what became a nationwide pattern between the 1930s and the 1960s, the only "surveying" service a surveyor alone could offer was boundary surveys. Surveyors could, like engineers, perform topographical and layout surveys as well, but they could not claim these traditional surveying services as theirs alone.

In a pattern that other states followed with minor regional variations, initial surveyor licensees were grandfathered by experience, with no particular education or exam required. When qualified by experience, over half of the newly registered engineers and surveyors became dual licensees, holding both Civil Engineering (C.E.) and Registered Land Surveyor (R.L.S.) licenses.

(Note that in the 1970s and 1980s some states changed the title *Registered* Land Surveyor, to *Professional* Land Surveyor. This change in title had nothing to do with whether an individual was grandfathered or had become a surveyor by exam. The distinction between registered and professional is discussed below.)

With the advent of surveying licensure, C.E.s who could not become registered by experience (that is, who were not grandfathered) had to complete five surveying courses to qualify: basic surveying, route surveying, advanced surveying, topographic surveying and geodetic surveying. Yet in the first decades of registration, R.L.S.s had no such requirement. They were largely trained by apprenticeship, and were licensed without the requirement for any college or advanced education. In those early decades, engineers rapidly won the race to be considered a learned profession.

By the late 1930s to early 1940s, surveying exams were required for land surveyors who were not already grandfathered; educational requirements remained minimal. Surveying was typically regulated under a combined Board of Engineers and Surveyors. This connection between surveyors and engineers remained until the 1970s. By that date land surveyors felt increasingly disenfranchised as the board member composition was frequently in the proportion of 7:1, engineers to surveyors. Many surveyors became overtly critical of their state boards.

### Land Surveyors Seek a Separate Identity

In the late 1930s and early 1940s, professional engineering societies began to appear in many states. Many of these societies created what were called Survey Sections. Land surveyors were not full members in many cases, but could become associates through membership in the survey section. Further, land surveyors were either barred from, or were infrequently elected, as executive board officers of these societies. The same disenfranchisement land surveyors felt in reaction to Boards of Engineers and Surveyors began to occur within the survey section membership of these professional societies.

By the mid-1940s to early 1950s, surveyors began to break away from engineering societies to form separate societies for surveying. Professional identities started changing. Surveyors lobbied state legislatures to have their titles changed from R.L.S. to P.L.S.—Professional Land Surveyor. They requested this change as a public recognition that they are professionals, not mere tradesmen. To many surveyors, R.L.S. as a title means that they simply hold state licensure that is no different than that held by a registered plumber, hairdresser or dietitian. P.L.S., on the other hand, to those uncertain that "registered" denotes a professional, described professional goals and aspirations.

This small revolution was, and in some cases remains, controversial. Not all states license surveyors as professionals, choosing to retain the older *registered* appellation. Although these states are now in a minority, all states require licensees to take the same exam administered by the National Council of Examiners for Engineering and Surveying (NCEES). NCEES notes in its literature under Licensure for Surveyors,

> Once you are granted licensure, you may use the distinguished designation "professional surveyor," or P.S. Some jurisdictions use other titles signifying the same expertise, for example, Professional Surveyor and Mapper (P.S.M.), Land Surveyor (L.S.), or Professional Land Surveyor (P.L.S.)

Note that NCEES does not use the word, registered.

The NCEES literature goes on to state,

> The profession regulates itself by setting high standards for surveyors, and by law, all jurisdictions require surveyors to be licensed in order to practice. These requirements and high standards help protect the public's safety and welfare.
>
> Licensure is the mark of a professional. It demonstrates accomplishment of the high standards of professionalism to which the surveying profession subscribes.

Although NCEES serves both engineers and surveyors equally, it has played an important role in the last 30 years for land surveyors. Before the 1970s, state boards used "in-house" exams for surveying licensure, administered and graded by the individual board. This gradually changed. In 1975 NCEES administered the first national fundamentals land surveyor exam, a one-day exam that was expanded in a short time to two days (the second day often incorporated a state-specific law portion).

Since that time, all state boards of licensure have moved to use of the NCEES exams. (Note that NCEES continues to administer separate tests for engineers and surveyors.) NCEES considers any surveyor having passed its exam a "professional." Words, as Thoreau well knew, are important.

### Engineers Decouple and Surveyors Seek an Expanded Scope of Practice

In the 1960s and 70s, university civil engineering programs began to cut back on the surveying courses offered. Surveying was not considered "design," a new identity that was sweeping engineering. Including the nuances and technique of measurement fell out of fashion within the engineering field. By 1970 the surveying profession had effectively lost its academic home. As surveying professors retired, few were replaced. Worse, interest in surveying programs declined among C.E. administrators.

Consequently, surveyors faced what many in the profession considered a crisis. Surveyors nationwide began to discuss broadening their profession. The expanded professional services have become known, particularly among academics, as geomatics.

In fact, much of the expanded scope that surveyors envisioned included services that many surveyors were already providing to sophisticated and technologically astute clients.

In the 1970s and 1980s, as a result of lobbying by surveyors, statutory definitions of surveying began to change. A number of states expanded the definition of surveying. Surveying in these states was newly defined to include measuring the size, shape, geodetic location, legal location (that is, boundaries) and topography of things on or attached to the earth's surface. This expansion made surveyors key players in the sweeping technological changes that were beginning to occur worldwide.

In addition, some states changed the descriptive "Land Surveying" to either "Surveying" alone, or expanded the description to "Surveying and Mapping." NCEES recognizes the new category. Registrants in Florida, for instance, are now titled Professional Surveyors and Mappers (P.S.M.)

In the 1990s states began adding photogrammetry to their definitions of surveying. In tandem NCEES modified their Model Law for surveyors in 1995 to expand the definition for surveying practice to include photogrammetry. The narrow license to perform only boundary surveys had suddenly been swept aside. The surveying profession moved from a boundaries-only licensure to one that embraced a broader, multi-disciplinary concept.

### The Creation and Acceptance of Academic Programs

By the early 1960s there was a growing interest in the creation of academic surveying programs. The first 4-year program was initiated at Fresno State College in California in 1966, followed in 1973 by the University of Florida, at the request of the Florida surveying association. Other states in this same period started two-year programs.

Additional universities established surveying programs, including Purdue in 1970, then Ohio State University and Virginia Tech in 1975. Wisconsin, Iowa and a number of other state universities followed.

These programs are increasingly becoming known as Geomatics Education, rather than surveying. Geomatics is considered to include the art, science and technology of determining spatial positions, and the collecting and measuring of information about the earth and environment. For several years there have been discussions between NCEES and academic institutions about whether geomatics is, in fact, surveying. As surveying evolves, these discussions are inevitable.

The number of colleges and universities offering two and four-year degree programs in surveying (or geomatics) are declining. This is largely due to lack of demand. As a result, the number of Ph.Ds is down, and universities have been forced to import talent (primarily from Canada, England and Germany). Despite these fluctuations, there are presently more than 20 ongoing programs nationwide. (See www.acsm.net for a comprehensive listing.)

### Continuing Education for Surveyors

Before continuing education became mandatory for surveyors in many states, a number of surveying seminars began to be offered across the country. These were created and hosted by both private vendors and, at times, professional societies. This trend became noticeable in the 1970s, and accelerated in the 1980s.

Surveyors who had not gone to college sought further technical training, and greater understanding of legal aspects of evidence and boundary analysis. Experts offered workshops in surveying theory, as well as intense seminars in rapidly changing technology.

By the mid to late 1980s many surveyors pressed their state boards to mandate continuing education as requirement for continuing licensure. By the late 1990s, many states had passed mandatory continuing education requirements. These requirements vary from state to state. Some state boards require registrants to report annual courses and hours; other boards do not. Required annual hours vary from state to state.

In response, numerous private entities, as well as universities, have begun offering specialized continuing education. Typically, courses are created and submitted to state boards for accreditation. Courses may be attended in person at workshops or at annual meetings of national organizations, or may be taken on-line.

## The Advent of National Survey Organizations

In the early 1940s a number of prominent, nationally recognized land surveyors created the first organization in the United States specifically formed to represent (and provide education to) surveyors. The American Congress on Surveying and Mapping (ACSM) was the result of efforts by many to create a national organization in the void of what had been an uncoordinated hodgepodge of scattered statewide groups.

ACSM describes its history as follows:

> The American Congress on Surveying and Mapping (ACSM) was founded in June 1941 and is incorporated as a non-profit educational organization whose goal is to advance the sciences of surveying and mapping and related fields, in furtherance of the welfare of those who use and make maps. ACSM also encourages the development of educational programs and supports publications that represent the professional and technical interests of surveying and mapping. The society… includes more than 5000 surveyors, cartographers, geodesists, and other spatial data information related professionals from private industry, government, and academia throughout the world.

Walter Dix, a former president of ACSM, further described the very early beginnings in an article for an ACSM publication:

> The birth of ACSM was envisioned by two men in a rowboat on Rainy Lake during the 1938 summer camp of Professor Jack Dodds of Iowa State College. These men were a surveying professor from a Kentucky school and a WPA official from Washington, D.C. …
>
> A year later, at the Surveying Camp of the Speed Scientific School in Kentucky, formation of a congress was weighted with a sense of urgency. A committee was formed with George Harding as chairman, and by1940, plans for the formation of a "national congress" on "surveying and mapping" were well underway. Manufacturers of surveying and engineering instruments were very active at this time too. Instrument makers pledged funds to get things started and to defray early expenses of publishing a bulletin.

> In June 1941, a three-day conference was convened at the Department of Commerce in Washington, D.C. to “discuss” the formation of a congress; but the enthusiasm of the 163 attendees was infectious, so much so that the congress was organized as a permanent entity at this meeting.
>
> Named originally the National Congress on Surveying and Mapping (NCSM), the organization’s name was changed at a later date to the American Congress on Surveying and Mapping to encompass members from Canada and South America.

ACSM has remained effective since that time. It represents surveyors before federal legislative groups, federal agencies and state boards, and is affiliated with international surveying groups. As early as 1990 ACSM partnered with the American Land Title Association (ALTA) to publish a national set of elective standards for Land Title Surveys. Those standards are the gold standard used by legal title industry and attorneys. The ALTA standards continue to be revised, modified and expanded on a regular basis.

In addition ACSM, through one of its affiliate organizations, NSPS (the National Society of Professional Surveyors), offers several certification programs for specialized sectors of surveying. The *Hydrographer Certification* is now well recognized. As ACSM states, the certification is

> considered by many Federal, State and local agencies as well as private firms, seeking subcontractors when evaluating technical proposals for marine engineering, surveying, and construction.

Most recently, FEMA (the Federal Emergency Management Agency) and ACSM/NSPS have recently partnered to create *Certified Floodplain Surveyors*. This program

> creates a certification for licensed surveyors that will allow for an expedited review of applications for letters of map amendment (LOMA) to Flood Insurance Rate Maps (FIRM). A pilot program has been conducted in North Carolina in conjunction with the North Carolina Society of Surveyors and the North Carolina Division of Emergency Management.

ACSM/NSPS also offers the *Survey Technician Certification* (STC) —a comprehensive national certification program for survey technicians. The STC provides a national benchmark for technical excellence, and may be considered a stepping-stone toward full licensure by state boards.

## Conclusion

American surveying has changed appreciably over the last 360 years. From the perspective of a contemporary surveyor, the art of measuring has been driven by the shift from mechanical instrumentation to electronic and digital devices. When surveying began in colonial days, angle-measuring instruments were only marked to the nearest five minutes. A modern surveyor routinely reads angles to the nearest seconds. Similarly, distance measuring has gone from the use of steel chains to electronic equipment. GPS as a new technology promises to carry accuracy in measuring far beyond what is known today.

Regardless of these technological advances—a phenomenon of the last two decades only—the rules governing boundary surveying remain constant. A surveyor's duties, particularly one who is a boundary specialist, are largely to recover and retrace original monumentation. State laws, court cases and numerous legal interpretations prevail the moment a surveyor sets foot on a property. The need to be familiar with the legal aspects of surveying has not been superceded by technology.

Although in several hundred years the American surveyor has gone from unlicensed expert to a professional practicing only with state sanction, the statutory definitions of surveying have expanded dramatically in the last quarter of the 20$^{th}$ century. Land surveyors have successfully decoupled themselves from a century-long association with the civil engineering profession, and carved out an expansive practice that includes determining the size, shape, geodetic location, legal location and topography of all things on the earth's surface.

A proud and ancient profession, land surveying is poised to continue its central position as a domain that uniquely combines measuring expertise with legal analysis. Even though surveying tools have evolved dramatically, Egyptian and Roman surveyors would immediately understand the work and tasks of today's land surveyor.

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### Acknowledgments

The author wishes to acknowledge the contribution to the surveying profession of James L. Conine, P.L.S, and Lee I. Kicklighter, P.L.S., of Brunswick, GA. They also contributed mightily to the author's education and development as a young surveyor. In addition, he notes the immeasurable contribution to the profession of Walter Robillard and Donald A. Wilson.