Volume 28: Issue 4
October, 2017

LINES & POINTS

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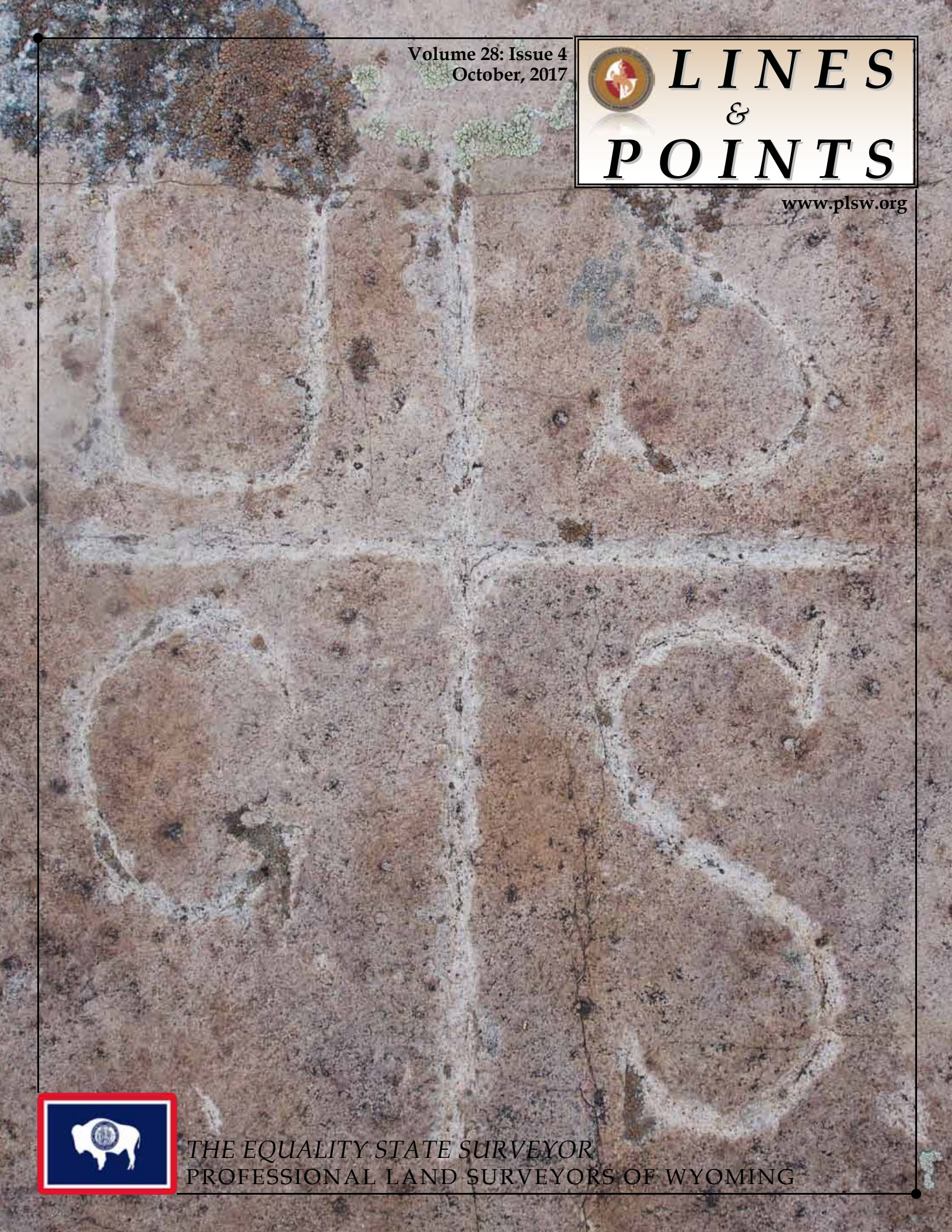
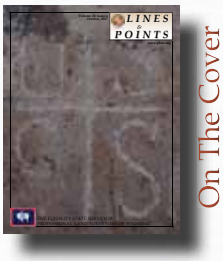


THE EQUALITY STATE SURVEYOR

PROFESSIONAL LAND SURVEYORS OF WYOMING



On The Cover

A USGS reference mark for the Jackson Peak station. This station was also used by Hayden in his 1877-78 triangulation. (Photo by Todd Cedarholm)

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2017 PLSW SUSTAINING MEMBERS

- Jenn Heinrich - Frontier Precision Inc.
- John Baffert - Surv-KAP, LLC
- Chris Farnsworth - RDO Integrated Controls
- Kelly Goff - Underground Consulting Solutions
- Susan Hall - Trimble
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- Troy Langston - Monsen Engineering

PLSW (Professional Land Surveyors of Wyoming; PO Box 8, Cheyenne, WY 82003) is a statewide organization of Land Surveyors registered to practice in the Equality State of Wyoming. PLSW is dedicated to improving the technical, legal, and business aspects of surveying in the State of Wyoming. PLSW is affiliated with the National Society of Professional Surveyors (NSPS) and the Western Federation of Professional Land Surveyors (WestFed).

Advertising Information

Digital-ready, full-color advertising with payment should be mailed to Lines & Points, P.O. Box 8, Cheyenne, WY 82003.

Advertising rates are as follows:	Year	Issue
Full Page	$810	$210
Half Page	$540	$140
Quarter Page	$310	$80
Business Card	$40	$10
Employment	Free	Free

Special Rates apply for PLSW Chapters and cover placements.

For more information please contact Jack Studley.

PRESIDENT'S MESSAGE

I'm always astonished at the amazing rate at which things disappear in my home. My wife and I are the parents of six children (yes, six), five of whom are in school this year. As I write this, the morning routine is beginning: "Mom! Have you seen my_____" (insert item in the blank), which can be somewhat frustrating, given that the item being sought, usually a shoe, was just on the foot of that child yesterday afternoon just before going to bed. Fortunately, we have yet to fight the battle of not wanting to go to school. Oddly enough, our children enjoy learning and associating with their peers.

I enjoy outdoor activities that do not require a motorized vehicle. One of my favorite pastimes is rowing. Having grown up rowing a big, clunky, aluminum rowboat, I had an opportunity to spend a few hours in a single man racing shell and thought I was in heaven. The ease of moving through the water and the speed attained from one's own strength was truly spectacular. You sit in the shell and it is just you, the oars, and the water. It takes some time to get both oars operating in unison, giving each an equal pull, but when it all works together, you feel as if you could pull a skier!

As I watched my children prepare for school and sat pondering on this wonderful profession of which we're a part, the oft discussed topic of education and experience wandered into the conscious mind. You see, in my family education is important. But, it is education coupled with learning. We do not want to raise children who know how to spout off memorized facts, but children who can apply acquired knowledge and skills to any situation. We send our children to school so that they will come in contact with many people who have a different way of viewing things, who might have a different perspective on a problem, and learn to work in an environment of cooperation to accomplish a task, in short, to become a well-rounded person who can see things from many points of view.

Without attempting to spark debate on the topic, each of these aspects of the professional is just as important as the other, just like the oars on a rowboat. Pulling too hard on one will cause the boat to turn away from its desired course. Each of us, likewise, must take time to educate ourselves and then put into practice the knowledge we have acquired. As the Fall Technical Session approaches, I encourage you to come with an open mind and ready to learn something new or to be reminded of something you already knew. Perhaps you will bring a young person who is interested in the profession and allow them to mix with other professionals and learn something from them, to ask questions and, just maybe, cause one of us to review why we do the things we do.

Karl Scherbel, P.L.S.
President, Professional Land Surveyors of Wyoming

ANNOUNCEMENTS

Inberg-Miller Engineers is excited to announce the acquisition of Bruce Engineering in Gillette, Wyoming. Long-time employees Jerry Williams, Scott Bruce, and Steve Bruce have agreed to become part of the Inberg-Miller team. We look forward combining our resources, skills, knowledge and expanded opportunities by providing excellent civil, geotechnical, and environmental engineering, surveying, construction materials testing, inspection, and environmental and geotechnical drilling services to the Gillette, Campbell County, and the entire NE Wyoming Region.

Inberg-Miller Engineers is an employee-owned, Wyoming-based engineering and surveying firm founded in 1971. We currently employ over 65 technical and professional staff in Riverton, Casper, Cheyenne, Green River, Douglas, and now Gillette. To contact us, please call at 307-682-5000 or visit our website at www.inberg-miller.com.

ANNOUNCEMENTS

OPUS – Projects Manager's Training

October 31 – Nov. 1, 2017

City Center Building
100 W. B Street
Casper, WY 82609

Sponsored by:
National Geodetic Survey
&
PLSW – Central Chapter

Instructors:
Bill Stone,
NGS SW Regional Geodetic Advisor
Pam Fromhertz,
NGS Rocky Mountain Regional Advisor

Class size: Limited to 25 participants
Registration Fee: $25.00 at the door, payable to PLSW – South Central Chapter

October 31: 8:00 am – 5:00 pm
November 1: 8:00 am – 12:00 pm
Lunch break will be on your own.

Registration: through the NGS web site at http://www.ngs.noaa.gov/corbin/calendar.shtml
For additional information contact: Mike Londe, PhD, 307-775-6209, mlonde@blm.gov

OPUS-Projects is an enhanced version of the popular NOAA/National Geodetic Survey utility, the Online Positioning User Service (OPUS). OPUS-Projects is a free, Web-based GPS multi-baseline processing and least-squares network adjustment package, providing simple visualization, management, and processing tools for survey projects including multiple survey marks and occupations. OPUS-Projects is a natural extension of OPUS, allowing surveyors, engineers, researchers, GIS and other geospatial professionals to position campaign-style GPS observations (geodetic networks) at a high level of positional accuracy, often achieving cm-level uncertainty relative to the North American Datum of 1983 (NAD83) and the North American Vertical Datum of 1988 (NAVD88).

By attending this workshop, you should have enough information to successfully use OPUS-Projects for your own geodetic network projects. The training is 1.5 days in duration, and by attending the full workshop you will become an authorized project manager for OPUS-Projects, allowing you free access to the program. The workshop includes both instructor lectures and hands-on participant work with a sample training project (each participant will be provided their own copy of the project), which demonstrates various capabilities of OPUS-Projects, including the ability to enhance a project's elevation accuracy by occupying published vertical control stations (aka bench marks). You are also welcome to bring your own GPS project data (survey-grade, L1/L2 GPS data) for processing during the workshop (the instructor can provide further details). You must bring a WiFi-enabled laptop computer with a current generation Web browser. The workshop will include an overview of geodetic concepts pertinent to optimal use of OPUS-Projects. The instructor will provide further details to all registrants prior to the workshop.

P.L.S.W. TECHNICAL SESSION

November 2ND & 3RD, 2017 • PARKWAY PLAZA • CASPER, WYOMING

GENERAL INFORMATION

PRE-REGISTRATION:

FEE: $100 PLSW Members
$50 PLSW Affiliate Members
$175 Non-Members

A $20 late registration fee will be added to all registrations received after October 24, 2017.

AGENDA

November 2ND	7:00 a.m. - 8:00 a.m.	Registration
	8:00 a.m. - 12:00 p.m.	Seminar
	12:00 p.m. - 1:00 p.m.	Luncheon
	1:00 p.m. - 5:00 p.m.	Seminar
	5:00 p.m. - 9:00 p.m.	Social Hour
November 3RD	7:00 a.m. - 7:45 a.m.	Breakfast Buffet
	8:00 a.m. - 12:00 p.m.	Seminar

LOCATION AND LODGING

A block of rooms has been reserved at the **Parkway Plaza, 123 West E Street**, Casper, Wyoming until October 21st. *Please note Wyoming State Volleyball is also during this time, so reserve your rooms early!*

Rate: $78 per night. Telephone: 307-235-1777.

PROFESSIONAL DEVELOPMENT HOURS

12 Professional Development Hours will be awarded for the entire seminar.

FOR MORE INFORMATION, CONTACT:

Paul Svenson 307-266-2524
Bill Fehringer 307-995-2620

Harriet M. Hageman
Water Law 101 for Professional Land Surveyors

Ms. Hageman's presentation will include an overview of Wyoming water law and history, including information about the State's statutory and regulatory framework, the State Engineer's Office, the Board of Control, permitting, water usage, property rights, changes, and abandonment.

Leah Bratton
State Engineer's Office, Surface Water Records and Research

Leah has presented over 40 classes showing how to use the federal public land survey system to find documents filed in the State Engineer's Office from the old "hard paper records" to the newest versions of the e-Permit system.

Christopher M. Brown
Colorado River Issues, Yellowstone River Compact Litigation

Chris's presentation will focus on current issues related to Wyoming's rights and interests in the Colorado River and the Yellowstone River Basins. He will also be available to address other water related issues or questions as time allows.

Sheri Culver
State Engineer's Office, Ground Water Records and Research

Sheri Culver has worked for the State Engineer's Office for over 20 years in the Ground Water Division. In April of 2017 she became the Executive Director of the State Board of Examining Water Well Drilling Contractors & Water Well Pump Installation Contractors.

Lines and Points Article Rotation Submission Schedule By Chapter

Responsible Chapter	First Call Date	Last Call Date	Publication Date
West Chapter	Thank You!!	(see "1901 The Sheridan Astro Station" in this issue)	
Central Chapter	December 1	December 15, 2017	January 1, 2018
South Central Chapter	March 1	March 15	April 1, 2018
Southeast Chapter	June 1	June 15	July 1, 2018
Laramie Valley Chapter	September 1	September 15	October 1, 2018
Upper Platte Chapter	December 1	December 15, 2018	January 1, 2019
Southwest Chapter	March 1	March 15	April 1, 2019
Northeast Chapter	June 1	June 15	July 1, 2019

ANNOUNCEMENTS

Editor's Comment: In recent years there have appeared in various news media articles describing the filing/recording in county clerk's and/or register of deed's offices various types of "fraudulent/ nuisance" liens and other legal papers affecting title of real property. These filings, which appear to the county officials to be valid title instruments have raised havoc when owners of these properties have attempted to provide clear title. In many instances, it has required months, and even years, to obtain legal decisions invalidating these fraudulent actions. In an effort to counteract these activities one county clerk has attempted to address the problem. The following article appeared in the *Foster's Daily Democrat* (Southeastern New Hampshire) on Friday, 22 September 2017, page A3.

The software used in this news story is a product of a third party.
More information about the software/service contact:

FIDLAR TECHNOLOGIES
350 Research Parkway
Davenport, Iowa 52806
(800) 747-4600

Register of Deeds Recommends Fraud Alert Service

Service will flag possible property, mortgage scam. Staff report: news@seacoastonline.com

DOVER - The Stafford County Recorder of Deeds urges property owners in the county to sign up for a free property and/or mortgage fraud alert service.

Register of Deeds Catherine Berube advises property owners to be aware of scams that involve property and/or mortgage fraud. The primary purpose of the fraud service is to help alert property owners to potential property and mortgage fraud. Citing the FBI, Berube said in a press release that property and mortgage fraud, a form of identity theft, is one of the fastest growing white-collar crimes in the country.

Potential fraud could involve someone recording a fraudulent document at the Registry of Deeds office to make it appear as if they own property that they do not legally own. Criminals may attempt to have counterfeit documents processed by the Registry of Deeds without the legal property owner's knowledge.

Property Fraud Alert is a free electronic notification service that alerts property owners if a document is recorded in their name, either as a grantee or a grantor. Property owners have the option of being notified by either email or by a phone. Subscriber information is not shared with third parties, Berube said. Once the property owner enrolls in Property Fraud Alert, there is no monitoring required other than to receive an email or phone call in the event the property owner's name is recorded in a property transaction located in the county or counties the property owner has designated.

Berube said even those who do not own property in Strafford County can sign up for the service and be alerted if a document is recorded with their name. Berube said her county has not experienced any widespread cases during her term in office. She has referred a few cases she felt were suspicious to the Strafford County Attorney's Office to investigate. County Attorney Tom Velardi said none of the cases the county investigated grew into criminal charges.

Those who wish to sign up for the service can do so at www.nhdeeds.com and click on the county where their property is located. It will navigate you to the registry of deed's website. Click on the link titled, "!!!Property Fraud Alert!!!" and that will bring you to the Property Alert site. com/straddordnh. Property owners may also call Property Fraud Alert directly at (800) 728-3858 for assistance.

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The Sheridan Astro Station

By Todd Cedarholm, PLS
Jackson, Wyoming

Map enthusiasts and collectors today are very fortunate that so many interesting and valuable maps that were previously available for study only in libraries or private collections have now been scanned and are available on-line to anyone. This was the case for me in 2013 when I discovered the trove of historical maps available on the United States Geological Survey website.

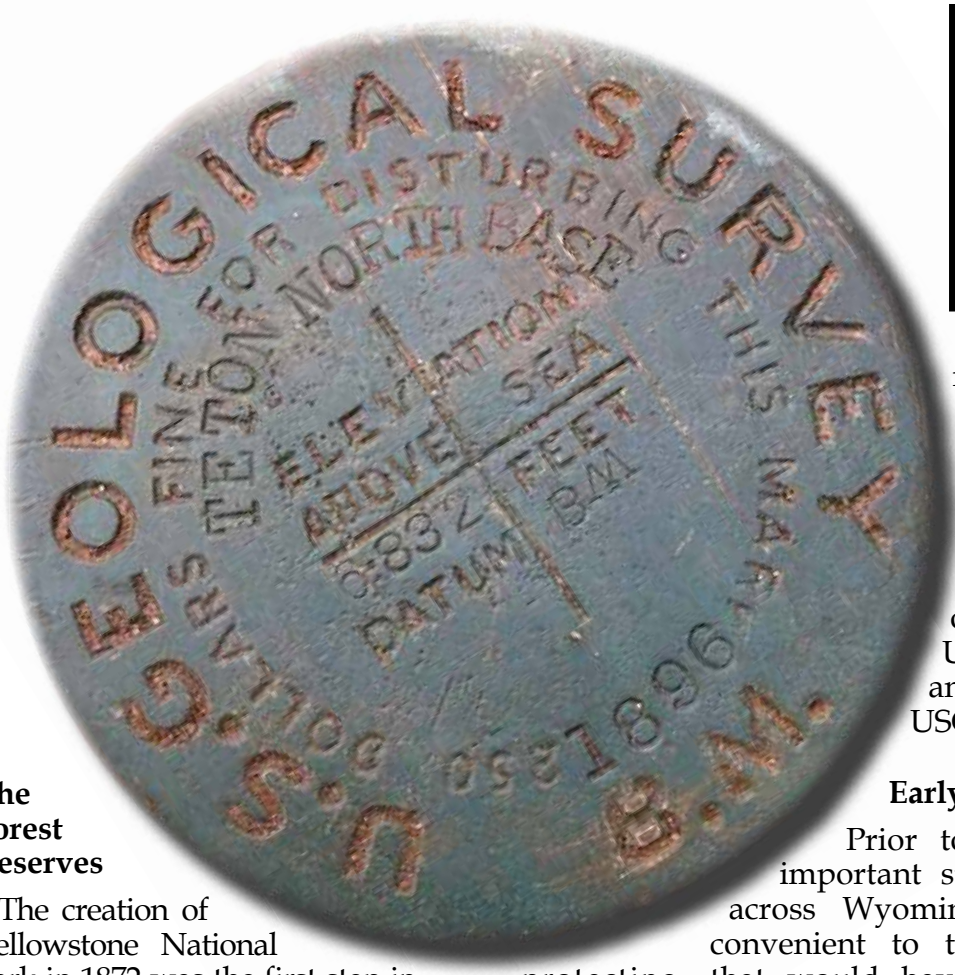
Astro station brass tablet detail with original latitude and longitude inscribed by S. S. Gannett.

As a long-time surveyor and occasional climber in Teton County, one map in particular caught my eye, the 1898 Grand Teton Quadrangle. The form of the map was very familiar and remarkably similar to modern USGS quads; the proportion of height to width of the sheet, crisp lines of latitude and longitude crossed the map, the PLSS/GLO grids were there, expertly drawn and detailed contour lines at 100 foot intervals, and a note that the "Datum is mean sea level". I wondered, "how did they accomplish this in 1898"? After some on-line sleuthing I ordered a copy of the 18th Annual Report of the United States Geological Survey from a used bookstore which describes the work of those early topographic surveys. Page 183 of the report includes a description of an "…astronomic station located at Sheridan Wyoming…at the corner of Crook and Fourth Streets…". Astro station was a new term to me, the hook was set, who can resist a good corner search?

I arrived in Sheridan just before dusk on a Friday in November, 2013, having just spent the previous few days with my fellow Wyoming surveyors at the annual Technical Session in Casper. I was there to search for the Sheridan Astro Station, one of the oldest United States Geological Survey geodetic marks in Wyoming. The NGS data sheet for the Sheridan Astro Station lacks recovery notes and includes the code "Surface mark reported destroyed". I was hopeful but not optimistic. I turned off of Sheridan Ave onto East 4th Street and followed it west toward the train tracks, a hundred feet before I reached the corner I saw it… The Sheridan Astro Station, a simple brick pier capped with a neatly dressed block of sandstone, inlaid with a circular brass tablet, it had been hiding in plain sight since 1896, undisturbed, at the corner of 4th and Crook Street, 400 feet southeast of the historic Burlington depot in downtown Sheridan.

Henry Gannett, Chief Topographer for the United States Geological Survey, assigned his brother Samuel S. Gannett, the task of establishing this precise geodetic point in the north-west corner of Wyoming where none previously existed. The United States Coast and Geodetic Survey Transcontinental Triangulation had bypassed Wyoming altogether, following the 39th Parallel. Therefore, unfortunately for the USGS surveyors, they were on their own to establish a precise geodetic position to begin their survey.

The position of an astro station was determined by repeated celestial observations, sometimes lasting a month or more, and for longitude determination, done in tandem with an established observatory via a telegraphic connection. The Sheridan Astro Station was to be the point of beginning of an extensive triangulation network that began on the east slope of the Bighorn Mountains, crossed the Bighorn Basin, the remote Absaroka Mountains, and terminated in Jackson Hole at the foot of the Teton Range . This network would be the control backbone for a dozen new topographic sheets covering the newly established Bighorn, Yellowstone, and Teton Forest Reserves.



Teton North Base 1896 brass cap set by T.M.Bannon at the north end of the Teton check baseline. This monument is also significant because the USGS first adopted a standard brass tablet in 1896 making this one of the oldest USGS caps in the country.

The Forest Reserves

The creation of Yellowstone National Park in 1872 was the first step in protecting and setting aside unique and important lands for the public. Congress soon recognized that there were other immense areas across the west with important timber, water, mineral, and wildlife resources that they believed could best be managed by the Government for the public good.

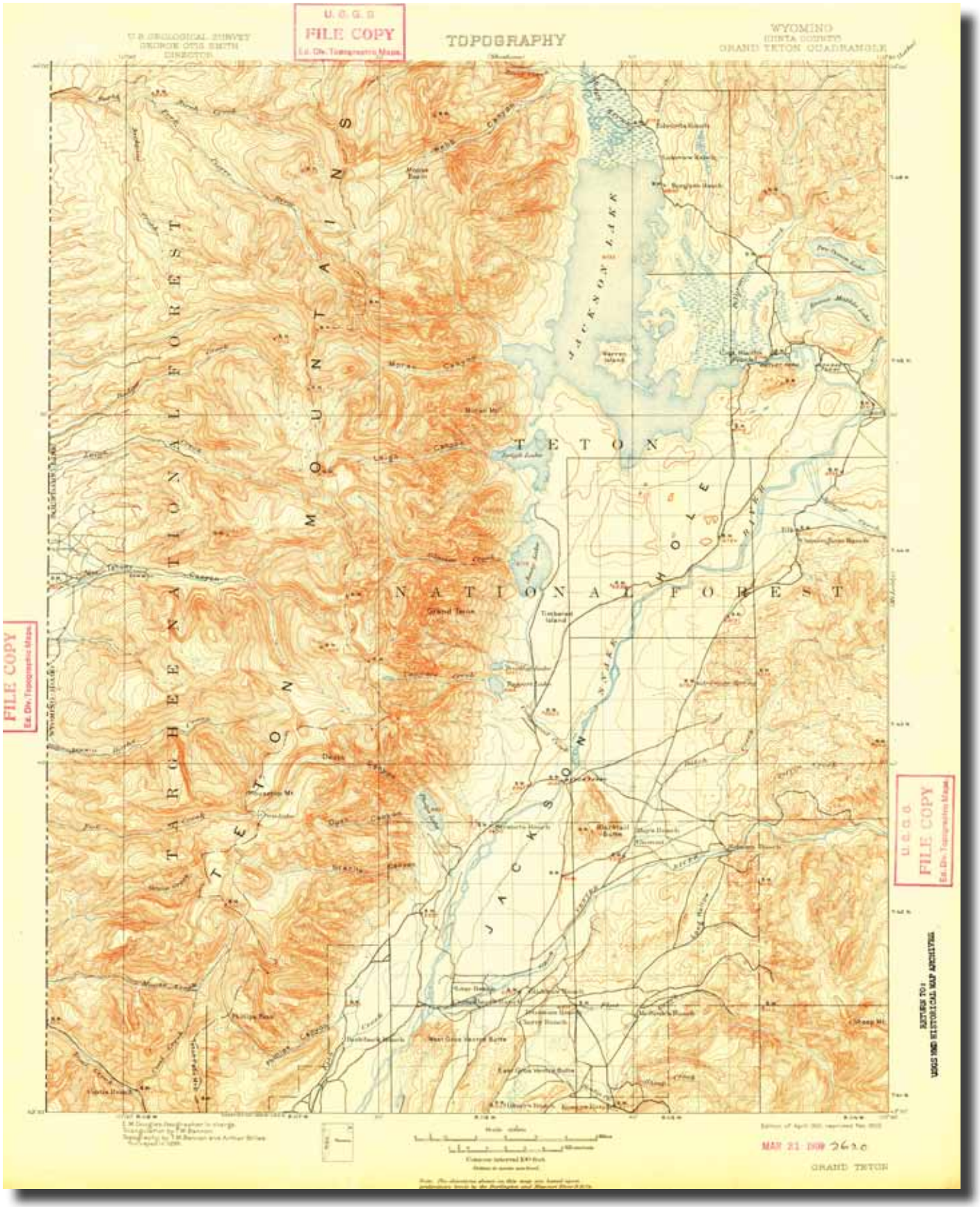
Congress approved the Forest Reserve Act of 1891 giving authority to the President to withdraw lands from the public domain as "forest reserves". By September 28, 1893 seventeen Forest Reserves had been established including the 1.2 million acre Yellowstone Park Timber Land Reserve adjacent to the new Yellowstone National Park.

On February 22, 1897, based on a recommendation by the National Academy of Sciences, President Grover Cleveland signed an executive order that established thirteen additional reserves including the Black Hills Forest Reserve, the Teton Forest Reserve, and the Bighorn Forest Reserve. These lands eventually became the first National Forests to be placed under the jurisdiction of the United States Forest Service.[1]

The Sundry Civil Appropriations Act of 1897 or the "Organic Act" created the statutory basis for which forest reserves could be established and managed, and the establishment of the Forest Reserves created a need for modern, complete, and accurate topographic maps. President Cleveland signed the act into law on June 4, 1897 and assigned the responsibility of mapping the reserves to the Unites States Geological Survey and appropriated $150,000 for the USGS to perform the work.

Early geodetic surveys

Prior to 1896 there had been some important surveying and mapping efforts across Wyoming but none that would be convenient to the forest reserve surveys or that would have provided geodetic positions considered acceptable. The 1872 Hayden Survey that produced the iconic map "Sources of the Snake River," did not utilize triangulation techniques for control of the survey. George M. Wheeler, as part of the 1872 Survey West of the 100th Meridian, established new astro stations in Bozeman, Montana and along the Union Pacific corridor in Laramie, Fort Steele, and Green River Wyoming. The Bozeman station was tied to a USC&GS base in Helena, Montana while all the Wyoming points were connected to the observatory in Ogden, Utah.[2,10] In an 1884 article for Science Magazine, Henry Gannet detailed discrepancies between the 1877-78 Hayden triangulation and the 1872 Wheeler work casting doubt on the accuracy of both surveys.[8,9] The USGS later used Wheeler's Bozeman astro station as a point of beginning for early topographic surveys of Yellowstone National Park. In the years between 1867 and 1872, Clarence King's Geological Exploration of the Fortieth Parallel, established an extensive triangulation network extending from the High Sierra of California, eastward along the fortieth parallel, through USC&GS astronomic stations in Verdi, Nevada and Salt Lake City, Utah, and finally terminating at the USC&GS Sherman Astro Station in Sherman,



The 1898 USGS Grand Teton Quadrangle.

The author photographing one of the north base reference stones. Four marked stones were set parallel and perpendicular to the base line to reference the base line marker.

Wyoming, the high point of the Union Pacific Railroad. The survey was directed by King himself and assisted by A.D. Wilson.[3] Even if the USGS had had confidence in their work, from a practical standpoint, the Wheeler and King surveys were too far removed from north-west Wyoming to be considered useful.

The Observations Begin

Having arrived in Sheridan by train from Washington, D.C., Samuel Gannett set about building his station and setting up a reliable telegraph connection to the Burlington depot. The pier "consisted of a foundation of a cubic yard of Portland cement concrete, with its upper surface level with the surface of the ground. On this a solid column of cemented brickwork 2 by 2½ brick lengths in cross section and 3 feet in height, is built, which is capped by a dressed stone measuring 8 by 20 by 24 inches."[1] A substantial pier not only served the purpose of preserving the observed position, since the observations would be made over a period of several weeks it was essential to provide a convenient and stable location to operate the heavy meridian transit. Faint remnants of the concrete or plaster that was used to secure the feet of the transit to the top stone are still visible today. A tent or small shack with a slit along the meridian would have been constructed over the pier and instrument for protection from the elements and the comfort of the observers.

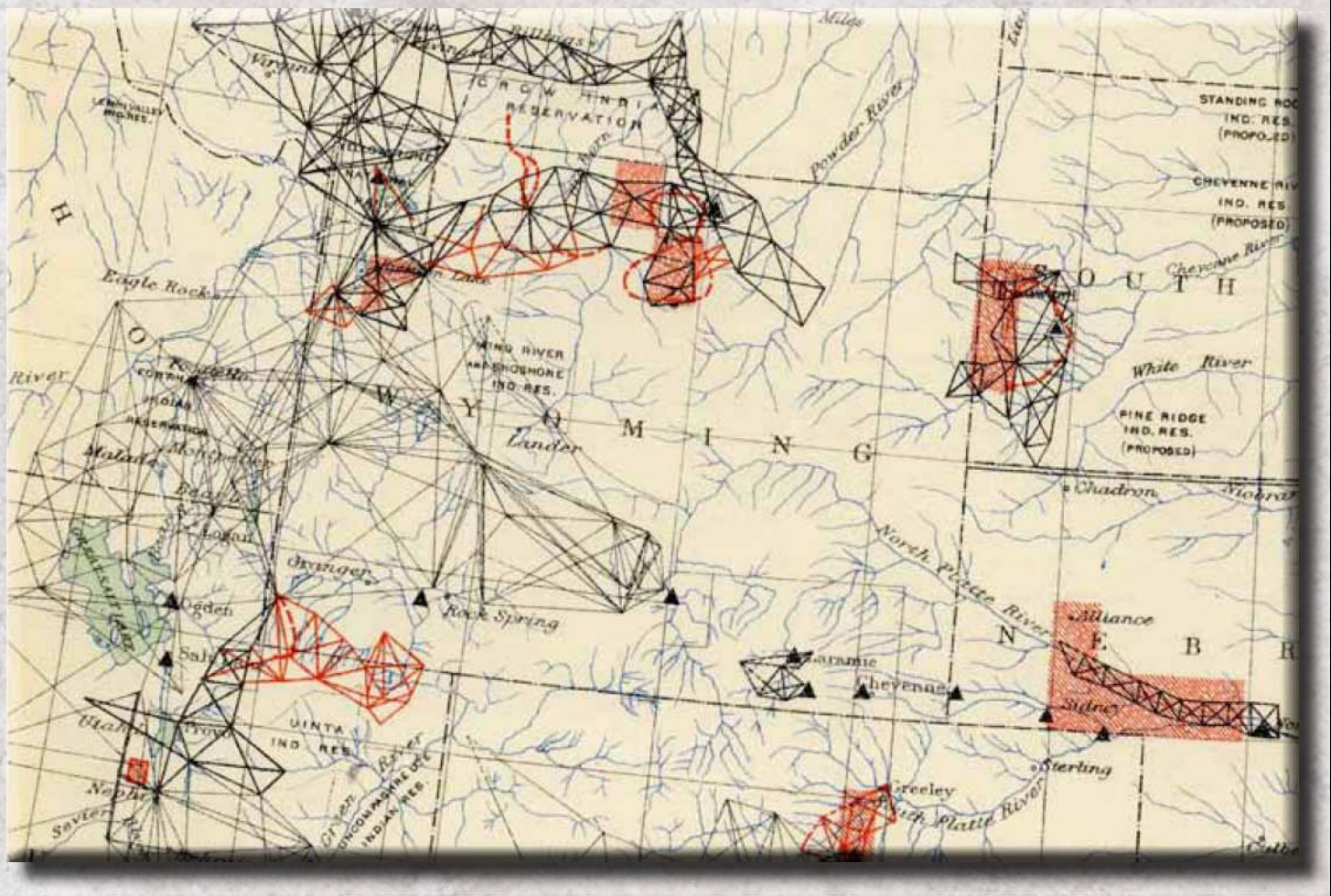
Latitude and Longitude

The latitude of the astro station was determined by the Horrebow-Talcott method, originally discovered by Danish astronomer Peder Horrebrow and later refined by Capitan Andrew Talcott of the U.S. Army Corps of Engineers. The procedure involved measuring the zenith distance between a pair of stars at meridian passage, one north of and one south of the observer's zenith. The latitude was subsequently calculated from the observed zenith distance between the stars and the known declinations of the stars. The beauty of this technique that improved the latitude measurements by an order of magnitude from earlier methods, was the fact that errors due to refraction were miniscule.[5]

The longitude of the astro station was determined by the telegraphic method. In this procedure, the

time difference at which the same star passes the meridian of two stations was determined when the observers at the two stations exchanged time signals by a telegraphic connection. The "base" station for this procedure is a point with a known longitude, usually an established permanent observatory, consequently, the longitude of the second station is easily calculated by the time difference between the star passages. This technique was pioneered by Commander Charles Wilkes of the U.S. Navy in experiments he performed in 1844 within a month of Samuel Morse successfully exchanging telegraph messages between Washington and Baltimore. One of the reasons Gannett most likely choose Sheridan as his point of beginning was because of a reliable access to the telegraph.

To introduce a distance component into the network Gannett measured a four mile long baseline with a 300-foot steel tape, beginning ½ mile north-west of the Ranchester depot and following along a tangent of the Burlington and Missouri Railroad. The line was prepared by nailing 6" pine boards to the ties as support for the tape, marks were made at each 300' length with a knife scratched into sheets of zinc tacked to the boards. Measurements were usually done at night, with the temperature being measured by two thermometers at each tape length. Because the baseline was much shorter than most lines within the triangulation network, the legs created off of the baseline were gradually increased in length, or expanded, to minimize errors from short back sights to long foresights.



A detail from a USGS map titled "ASTRONOMIC LOCATION, PRIMARY TRIANGULATION, PRIMARY TRAVERSE, AND SPIRIT LEVELING for the fiscal year 1899-1900". The large double triangle marks the location of the Sheridan Astro Station, the smaller triangles mark the locations of earlier astro stations surveyed by the USC&GS and the Wheeler survey. The heavy black lines denote the USGS triangulation network between Sheridan and Jackson Hole. The lighter black lines denote the 1877-78 Hayden triangulation.

Post, Bannon, and Tweedy Begin the Work.

Triangulation

Having established their position and surveyed a baseline the triangulation process was begun. Utilizing classical triangulation methods spelled out in Henry Gannett's 1893 A Manual of Topographic Methods, Mr. W. S. Post continued the work of 1896 and extended the triangulation westward from Sheridan to Heart Mountain on the west side of the Big Horn Basin, southward to Cloud Peak, and northward to the Montana line, occupying a total of 24 new stations. In 1897, T. M. Bannon extended Post's network to the south-west of Cloud Peak occupying ten new stations. Bannon also extended Post's work westward 75 miles beyond the 109th meridian to Mt. Sheridan and Younts Peak in the Yellowstone country. Frank Tweedy continued the network west and south occupying an additional 9 stations.[1] The triangulation was completed in the 1898 by Bannon and Tweedy during a long-ranging and busy season. They connected the network to the Lake astro station established in 1892 by C.H. Sinclair and G.R. Putnam of the United States Coast and Geodetic Survey. The station was established on the shore of Yellowstone Lake near the newly constructed Lake Hotel which conveniently provided a telegraph connection to the base station in Helena, Montana.[6] A five-mile long check baseline, known as the Teton Base was measured in the sage flat at the base of the Tetons, this area is labeled on current maps as "Baseline Flat". Six new stations were added for the base expansion and fifteen new stations were occupied to complete the belt of triangulation from Sheridan. All in all, over the course of three field seasons; Post, Bannon, and Tweedy established and occupied 60 triangulation stations spanning almost 200 miles and setting the control for over a dozen new topographic quadrangles.[7]

The Lake Astro Station in Yellowstone National Park established in 1892 by the USC&GS.

T.M. Bannon and Arthur Stiles spent most of the 1898 field season with plane table and alidade mapping topography for the Grand Teton Quadrangle. Many believe this sheet to be one of the most impressive USGS topographic maps. During that season Bannon and his crew made many first ascents of Teton Peaks including 11,939 foot Buck Mountain.[7] At the time, Buck, was the second highest summit attained in the Tetons behind the Grand Teton. William Owen, a GLO surveyor, mountaineer, and tireless self-promoter, was also in the Tetons during the 1898 field season. Reverend Frank Spalding led Owen and four others to the summit of the Grand Teton on August 11 to claim the first undisputed ascent of the peak. The team erected a large stone cairn and flag on the summit as proof of their accomplishment. Bannon and his USGS associates, having completed their triangulation network and establishing the control for the topographic map, sighted the flag from points on the valley floor. These observations were the first triangulated measurements to the summit of the Grand. Bannon's elevation of 13,747 feet is remarkably close the current accepted elevation of 13,775 feet.

Discovery, Recovery, and GPS

Together with my wife and business partner Jennifer Ziegler, I have climbed quite a few peaks in the Teton, Gros Ventre, Absaroka, and Wind River mountain ranges but it wasn't until we started this project that we realized we had been walking right by some very interesting surveying history. The first mark we discovered was the beautifully engraved USGS reference mark on Jackson Peak in the western Gros Ventre. We soon discovered similar marks on Sheep Mountain in the Gros Ventres, Buck Mountain and Fossil Mountain in the Tetons, and Blacktail Butte above Moose, Wyoming in Grand Teton National Park. We were successful on 13,166' Cloud Peak in the Big Horns barely noticing the weathered USGS carved into the summit boulder but stymied on climbs of Younts Peak in the Teton Wilderness and Franc's Peak, the highest summit in the Absarokas. We also made a special trip to Yellowstone to "recover" the Lake Astro station. Finally, the north and south Teton Baseline points were familiar to me from earlier work we had done in the Park but I hadn't understood their significance at the time.

In spite of our limited time and resources we were very interested in making GPS measurements between Jackson Hole and Sheridan, not as a rigorous exercise, but simply to obtain a sense of the quality and accuracy of a 19th century triangulation survey. Our method was to perform OPUS surveys of the two Teton Baseline points and the Sheridan Astro Station giving us the data to compare ellipsoidal distances. The Teton North Base point was occupied for 4 hours in September 2013 and the Sheridan Astro Station was occupied in November 2014. The Sheridan survey presented a survey problem in that large trees hang over the pier making a direct measurement impractical. To address this we set a point in the clear on the west side of Crook Street approximately 100' from the pier. This point was occupied for two hours and during that time we made a 10 minute RTK occupation of the pier itself. The ellipsoidal distance based on data from the 1899 USGS report was found to be 1,049,204.46 feet. The distance based on our OPUS occupations was found to be 1,049,122.473 feet, a difference of 81.99 feet.

Summit marker on Black Tail Butte, Grand Teton National Park. This point was part of T.M. Bannon's network in Jackson Hole, it was also included in Hayden's 1877-78 triangulation and is probably one of the oldest metal survey marks in Wyoming.

Conclusion

The Sheridan Astro Station, the Sheridan to Jackson Hole triangulation network, and the Teton Baseline are a unique collection of important artifacts contributing to our Wyoming surveying legacy. This system may be the only intact 19th century USGS triangulation network that includes an undisturbed original point of beginning connected to an undisturbed check baseline two-hundred miles away. Many of the original marks we recovered are located within Grand Teton National Park or wilderness areas, and because of their remote locations are probably safe from destruction. However, the Sheridan Astro Station's pristine condition is unique and because of its urban location it is extremely vulnerable to damage or destruction. The hope is that its preservation could become a priority for Wyoming surveyors, the City of Sheridan, and the State of Wyoming.

Acknowledgements

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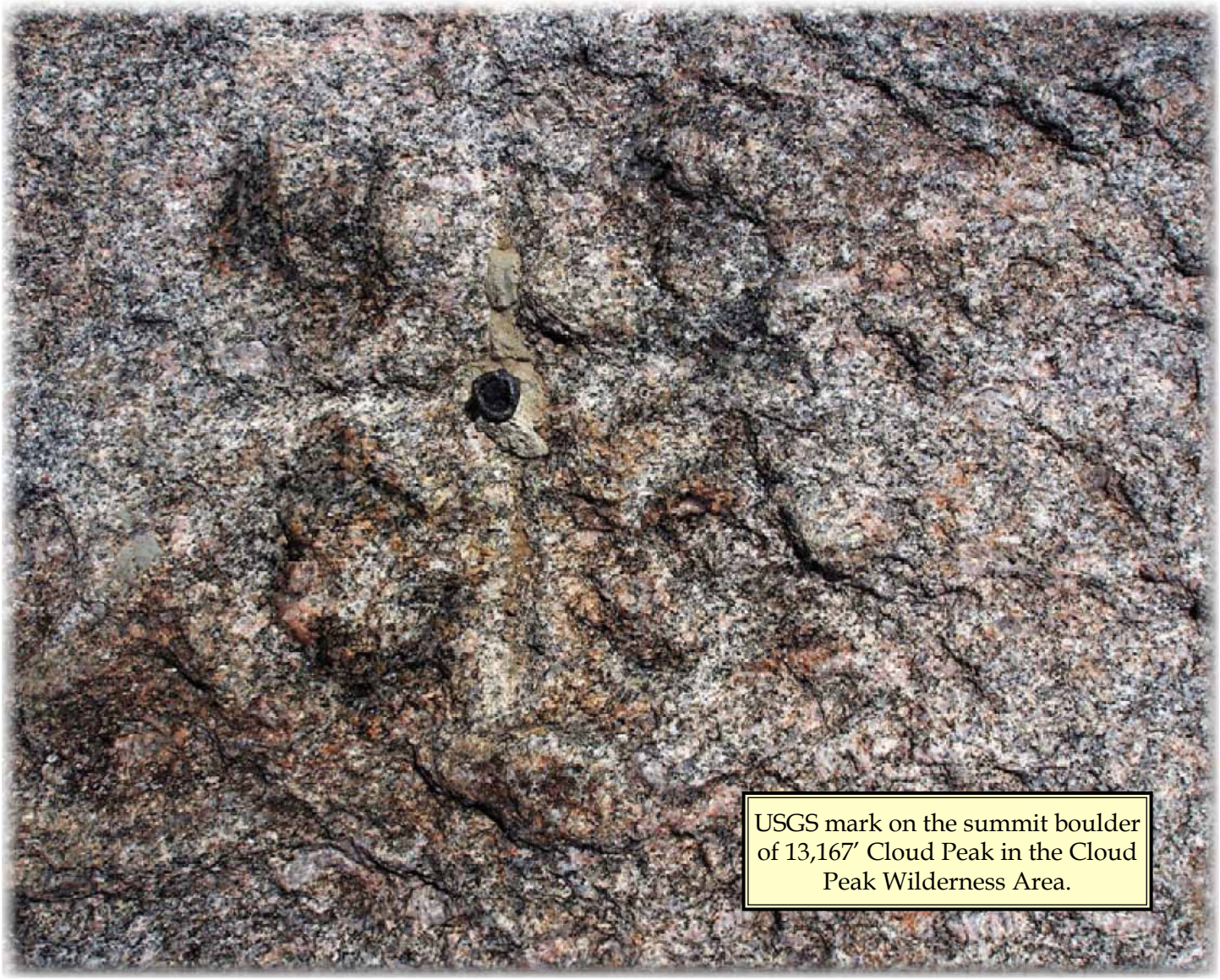
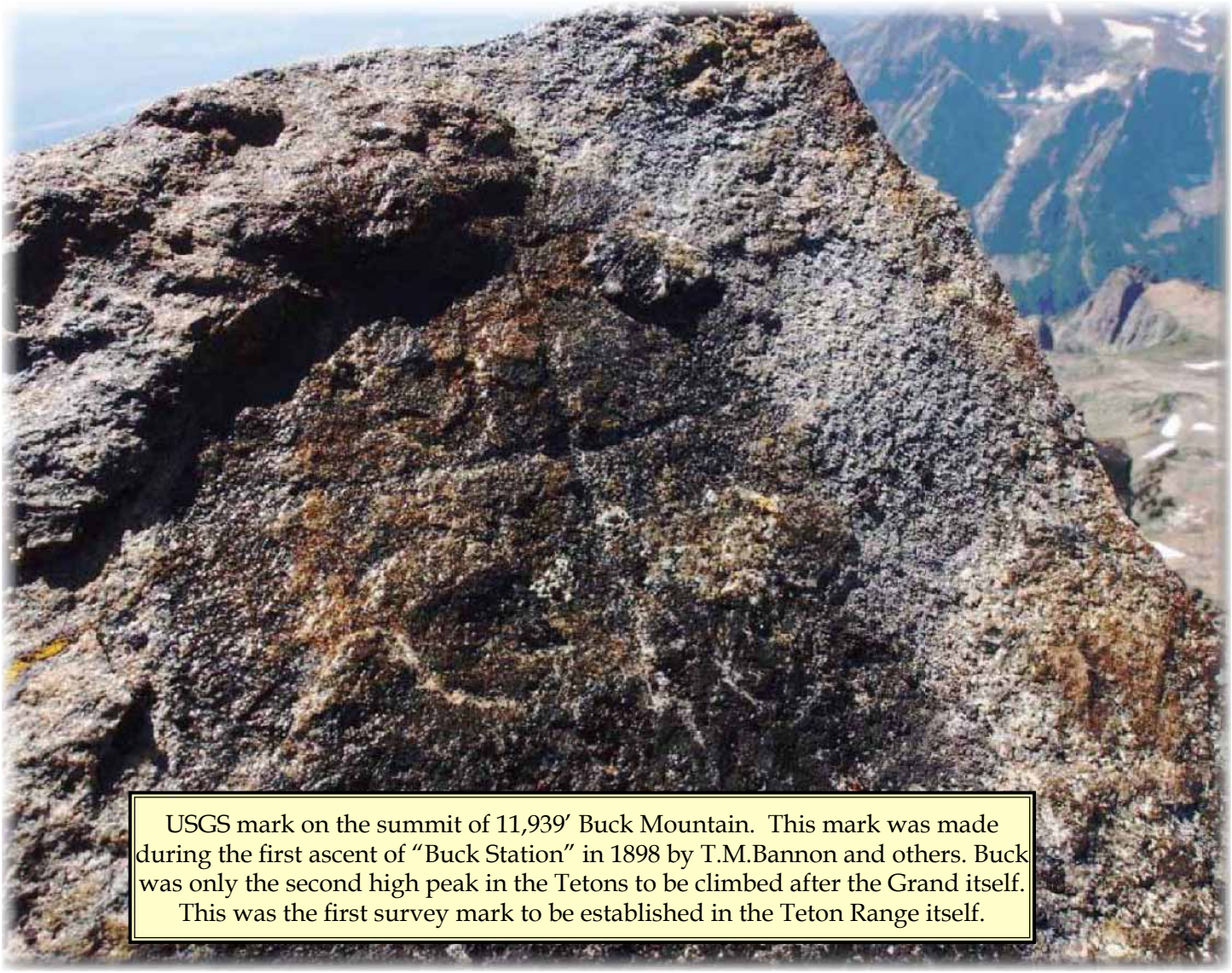
The Sheridan Astro Station was also documented in a WyoFile article, "Wyoming monument to the middle of nowhere" by Angus M. Theurmer, published July 5, 2016. www.wyofile.com



USGS mark on the summit boulder of 13,167′ Cloud Peak in the Cloud Peak Wilderness Area.



USGS mark on the summit of 11,939' Buck Mountain. This mark was made during the first ascent of "Buck Station" in 1898 by T.M.Bannon and others. Buck was only the second high peak in the Tetons to be climbed after the Grand itself. This was the first survey mark to be established in the Teton Range itself.

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Geodetic Surveying: Part XII

Alexander Dallas Bache and the Coast Survey: Part 1

Herbert W. Stoughton, PhD, PELS, CP

With the passing of Ferdinand Rudolph Hassler (20 November 1843), there were several candidates to the superintendency of the Coast Survey. These were James Ferguson, Coast Survey Assistant; Simeon Borden, who conducted field surveys at the Massachusetts Trigonometrical Survey; Captain Andrew Talcott, U.S. Army Topographic Engineers; William Strickland, consulting civilian architect and civil engineer; and Alexander Dalles Bache, great grandson of Benjamin Franklin. Bache was a well known member in the American science community. The Secretary of the Treasury, John C. Spenser, supported Ferguson.

Even before Hassler's death, there were individuals who favored Bache to succeed Hassler, there was a campaign by the prominent members of the American scientific community supporting Bache. Joseph Henry, future head of the Smithsonian Institution , and John Kane, Secretary of the American Philosophical Society , were the early instigators.

Bache was born on 19 July 1806. He was the grandson of Alexander James Bache, who was the Secretary of the Treasury, at the time of Hassler's appointment as Coast Survey superintendent (1807). Bache entered West Point as the youngest cadet in his class, and graduated head of his class in 1829. He held the distinction of never receiving a demerit while attending the Academy. Upon graduation, he was assigned instructor (of mechanical engineering) for one year. His next assignment was under Colonel Joseph Totten, as an engineer to construct Fort Adams (Newport, Rhode Island). He became a primary editor of the Journal of the Franklin Institute. In later years, Bache, as superintendent of the Coast Survey, and Totten, as head of the Corps of Engineers, would work together on numerous projects. After two years at Fort Adams , Bache resigned his commission and accepted as appointment of professor of natural philosophy and chemistry at the University of Pennsylvania.

Bache spent seven years at the University of Pennsylvania . During the period he reputation as one of the leading scientists in America was established. He established the first magnetic observatory in the United States; studied the winds of tornadoes; investigated the relation of rainfall and wind direction; reported on water power; and reported on the explanation of steam boilers. On 19 July 1836 (his 30th birthday), he accepted the position as president of Girard College (in Philadelphia). Stephen Girard, created an endowment to build a college for orphans. One of Bache's first assignments was to study European educational institutions. Bache visited 278 institutions in 26 months, and wrote a 666-page report.

In January 1834, Bache authored "Report of the Managers of the Franklin Institute , in Relation to Weights and Measures" (Journal of the Franklin Institute ; v. xiv; p. 6). It was probably during this period that Bache and Hassler met. Also, Bache's brothers, George Mifflin Bache and Richard Meade Bache, were naval officers attached to the Coast Survey during Hassler's tenure. George's brothers-in-law, David Dixon Porter and Carlisle Pollock Patterson, also served at the Coast Survey during that time. Porter would head the Navy during the American Civil War, and Patterson would be the fourth superintendent of the Coast Survey. John James Abert was Bache's brother-in-law and the first assistant of Hassler. A second brother-in-law, Major W. H. Emory, was head of the Mexican Boundary Survey. Also, a cousin, Major Hartman Bache, was associated with coastal surveys and engineering and lighthouses for many years.

After Bache returned from Europe, he remained at Girard College for approximately one year. He then moved to Central High School of Philadelphia , the first public high school in the United States outside of New England. This institution would play an important role in the Coast Survey, as numerous graduates were employed by the Coast Survey, and would have illustrious careers. The school was equipped with an astronomic and magnetic observatories. Bache would exert profound influence on American secondary education. The four-year academic program was designed to prepare the students for life in the professions. Bache also designed an academic program for students interested in classical studies and for students interested in the trades or could not spend four years in school. Bache's affiliation with Central High School of Philadelphia would be extremely beneficial to the

Coast Survey. He recruited George B. Davidson, James Lawson, Alexander Harrison, Stephen and Joseph Harris, Frank Hudson, and Joseph Ruth for Coast Survey employment. In mid-1842, Bache departed Central , and returned to the University of Pennsylvania

Although Hassler was a renowned scientist in America, he had very few contacts with other scientists, except at the American Philosophical Society . Bache was the opposite, and understood the importance of developing a strong and friendly scientific relationships as a political tool.

President John Tyler appointed Alexander Dallas Bache superintendent of the Coast Survey on 11 December 1843. Secretary of the Treasury, John C. Spencer, desired to have the principle of seniority followed, which meant James Ferguson would be appointed superintendent. For the next few years, Bache and several of the Coast Survey assistants from the Hassler era would have personnel issues. Ferguson (in 1845) was assigned to measure the Kent Island Base Line (a verification base line) opposite Annapolis, Maryland, connecting the most southerly extension of Hassler's triangulation. The resulting observations were found defective. A board of investigation was convened. The Board included Professor Benjamin Peirce (Harvard University); Captain Andrew Talcott (U.S. Army Topographic Engineers); and Professor Charles Davies (West Point). The Board reported their findings to the Secretary of the Treasury, Robert John Walker (19 July 1801 - 11 November 1869). Ferguson's work was rejected, and he was terminated.

The second personnel problem facing Bache early in his tenure as superintendent of the Coast Survey and Office of Weights and Measures was with Hassler's son Edward Troughton Hassler. Edward Hassler was one of several senior Coast Survey assistants who confronted Bache with animosity and insubordination. To them, Bache was an outsider and "a mere college professor". The younger Hassler had been F. R. Hassler's principal assistant in the Office of Weights and Measures for the previous ten years, and thought that he would ascend to assistant and foreman for the construction of weights and measures. The younger Hassler resigned on 20 January 1844. Joseph Saxton, previously employed at the U.S. Mint in Philadelphia, was appointed to the position. Shortly thereafter, Bache's appointment

to be superintendent of the Office of Weights and Measures was announced, to accompany his superintendency of the Coast Survey.

In 1844, Bache revised the existing regulations and formalize them in Arrangements and Directions for Executing the Survey of the Coast, According to the Plan Approved by the President on the 29th April 1843 . This document was a detailed instruction describing the organizational structure of the Coast Survey and the Office of Weights and Measures, including definitively defining the administrative lines of communication within the Coast Survey and between the Coast Survey and the Department of Treasury. Secretary of the Treasury, John C. Spenser, was very happy to sign the document on 15 April 1844, because of the unstructured organizational operation under Hassler.

For the first one-half of 1844, Bach struggled with establishing and learning the precise/ accurate nature of the work (as demanded by Hassler). The latter was evident with the encounters with Ferguson and the surveys of the Kent Island Base Line and the connecting network, and with Edward Troughton Hassler. Some historians described this period as being an acrimonious encounter between the Hassler old guard and Bache. This has been supported by the dismissal of Ferguson and resignation of E.T. Hassler, who committed suicide on 14 June 1844. This definitely was not the case, as Hassler's second son, John James Scipio Hassler, who had assisted his father from the beginning of the Coast Survey, continued to work at the Coast Survey until his death in 1858. Bache realigned the Coast Survey by instituting strong ties with the Army officers and assigning them to survey parties and administrative positions. Through the years, Bache sought capable civilians (Charles O. Boutelle, Massachusetts trigonometrical Survey; ana a number of graduates of Central High School of Philadelphia .

Another aspect of Bache's realignment was to develop political and scientific ties needed to gain governmental support. His political ties included George Miffin Davis (uncle), Vice-President of the United States; Robert J. Walker (brother-in-law), former U.S. Senator and Secretary of the Treasury; William Wilkins (brother-in-law), U.S. Senator of War; and Jefferson Davis (personal friend), U.S. Senator. Dr. Bache cultivated the academicians in mathematics, statistics, astronomers, and the natural sciences. Some historians termed this effort as "expanding the intellectual base". Among this latter group were Benjamin Peirce (Harvard - mathematics); Louis Agassiz(Harvard - naturalist and paleontologist); Elias Loomis (New York University); Jacob Bailey (West Point - microscopist); Maria Mitchell (astronomer); Ormsby M. Mitchell (Cincinnati Observatory - astronomer); William Cranch Bond (Cambridge Observatory - astronomer); E. Otis Kendall (Central High School of Philadelphia - astronomer); and Stephen Alexander (Princeton - mathematician and astronomer). With Joseph Henry at the Smithsonian Institution , there was formed a close bond between the intellectual/ academic community and the political community.

In 1844, Bache's goal was to complete Hassler's program and expand the Coast Survey operations to encompass geophysics and oceanography. The primary effort was to measure verification base lines north and south of the Fire Island Base Line. As previously mentioned, Kent Island would be the southern verification base line. The northern verification base line would be near Boston, Massachusetts, and has a unique beginning. Charles O. Boutelle was the first assistant Bache hired, and had worked with Simeon Borden on the Trigonometrical Surveys of Massachusetts. Boutelle was attached to the northern triangulation of the Coast Survey, and suggested using an unused portion of a railroad bed near a baseline Borden had measured for the Massachusetts Trigonometrical Survey, which was through thick, hilly woods. The resulting base line was on the Boston and Providence RR in Bristol County, Massachusetts, and about 7½ miles north and east of Providence, Rhode

Island. Its reduced length was 17,326,3763 meters (56,844.953 feet - 10.7661 miles). In 1902, this base line was the longest base line east of the Mississippi River, and the third longest base line in the entire United States. The estimated probable error was ± 0.0358 meters (1:484,000 or 2.07 ppm). Assistant E. Blunt observed the angles at Massachusetts North and Massachusetts South Base . Bache observed the angles at stations Beaconpole , Bluehill , Manomet , Copecut , and Central Meadow. This configuration is called a triangulation base network, and in this case represents a rather complex one (Figure 1).

In 1844, Bache initiated an ambitious program of determining differences in astronomic longitude between observatories in the United States and Europe. Lunar occulations were the common procedure. The minimum requirements were a single observer and accurate astronomic tables. Until the availability of time signal transfers, first by telegraph, and later by radio, lunar occulations were the preferred method to determine differences in longitude.

At the same time, Bache enlisted the assistance of Hassler's old friend, Professor James Renwich. Renwich was requested to conduct a systematic campaign of magnetic observations at fixed stations along the coast. The variation of the magnetic compass was very important to mariners. This program and the subsequent research investigations were the first geophysical investigations undertaken by any U.S. agency. In the 1870's, a similar program was initiated for gravity. By the end of the nineteenth century seismological studies were added. Bache's initial steps in 1844 would make the Coast Survey and its successor the Coast and Geodetic Survey, to be the Federal leader is geophysics for over a century.

Also, a cadre of young Navy officers conducted systematic tide and current surveys to support the hydrographic survey requirements for charting. This program paralleled a similar investigation being conducted in the British Isles. The Reverend William Whewell compiled fourteen seminal papers on the tides. The papers and observations generated would provide invaluable data and insights for George Howard Darwin (8 July 1845 - 7 December 1912), the first eminent English mathematical geophysicist.

From 1845 to 1849, the work expanded considerably. In this period, Coast Survey parties had operated in states from Maine to Texas. In coastal areas, where there was little or no topographic relief, Edmund Blunt designed unique tripods to elevate the theodolite and observer over visual obstructions. Blunt employed lumber

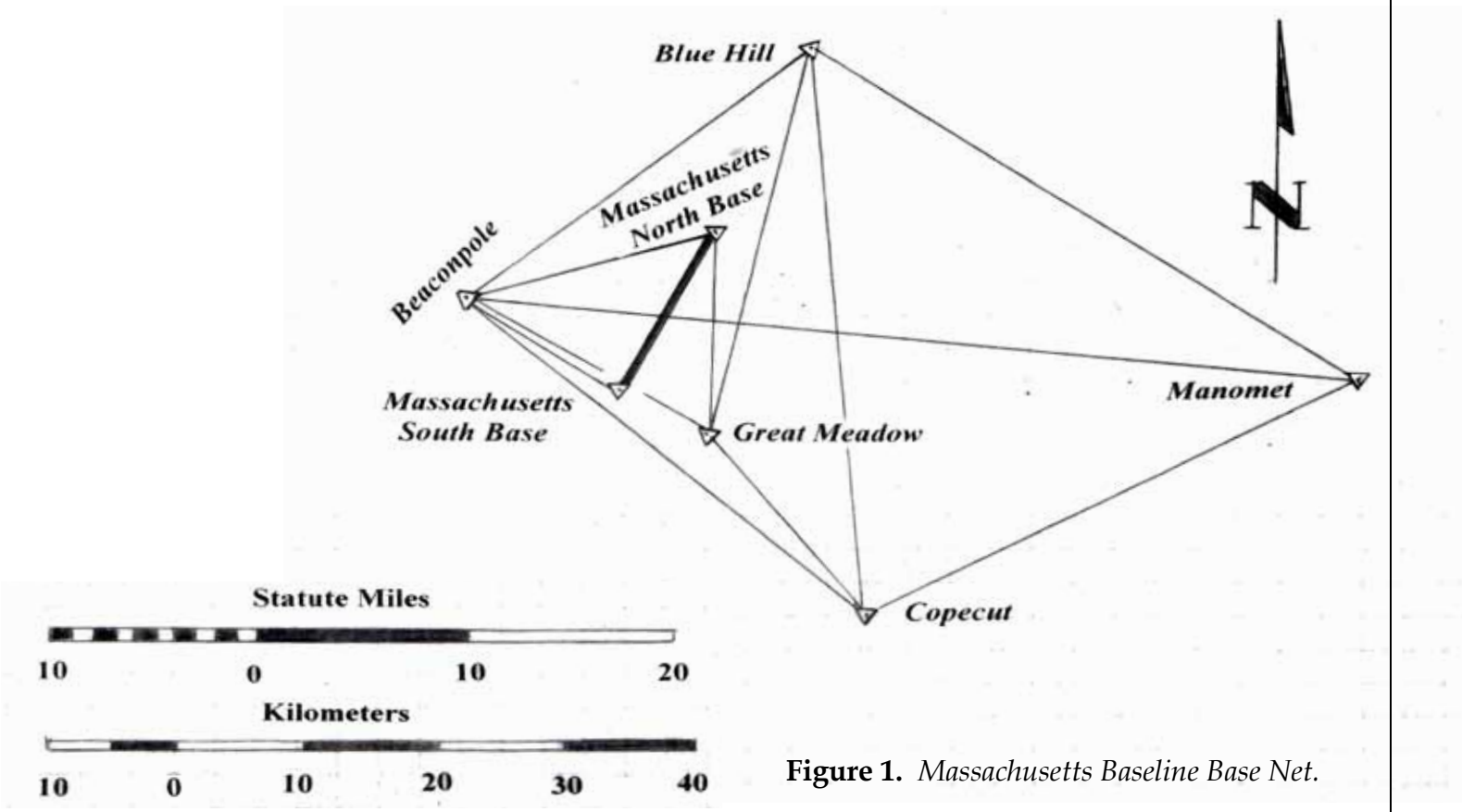

Figure 1. *Massachusetts Baseline Base Net.*

to make inexpensive, reusable towers and scaffolds, which could be moved from station to station. These units elevated the observer and theodolite from 30 to 45 feet above the ground. The scaffold was for the observer, and the inner tripod was for the theodolite or signal. The two units were not interconnected, which precluded dis-leveling the theodolite when the observer moved around the scaffold to point on individual targets (around the horizon).

In 1845, William Würdemann produced a new baseline measuring apparatus. The subsequent geodetic literature calls it the Würdemann Apparatus or the Bache-Würdemann Apparatus. It was a bar constructed of two different metals, invariable in length with changing temperatures. This unit was similar to the Colby Apparatus discussed earlier in this history. The Bache-Würdemann Apparatus was very portable and measurement rates were greatly increased. Bache directed the observations in 1847 at Dauuphinn Island, Alabama. The base line was 10,661.8376 meters (34,979.712 feet, 6.6249 miles). The reported uncertainty was ± 0.0258 m. (1:411,000 or 1.43 ppm). This line was measured (and remeasured for a check) in seventeen working days! Another base line, the Bodie Island Base Line was measured in 1848. The base line was approximately 6.75 miles long. The estimated probable error was ± 0.0127 m. (± 0.042 ft.). It required only ten working days to measure!

In high school history books, readers learn that Samuel B. Morse invented/developed the telegraph. Within two years, Bache and his assistants, applied the transfer of electronic signals to astro-geodetic surveying. The procedure was to note the difference in time between two sites when the same astronomical even occurred. For the difference in longitude procedure, it was to place the vertical axis of rotation of the theodolite telescope into and coincident with the meridional plane. Then, near the center of the field of view, the time was noted/recorded when the star transited the meridian as indicated by the middle (central) vertical wire/thread of the reticule. Thus, knowing the exact time the star transited the meridian at an

observatory and the time the same event occurred at the second station, the time difference equates to the difference in longitude.

Because the telegraphic determination of longitude became a defacto result, the geodetic community were able to investigate minute differences, which were not previously suspected. These included the personal equation and minute instrumental errors. The next improvement was the invention of the chronograph (time-graph) by Joseph Saxton.

The chronograph is a graphical recorder of elapsed time. The instrument contains a cylindrical drum upon which is placed a blank sheet of paper. The drum rotates at a uniform speed (hopefully). An ink pen or pencil (scriber) is attached to an armature which moves parallel to the longitudinal axis of the drum and marks the paper. As the drum rotates, the pen is advanced with the axis and marks a straight line. Attached to the scriber is a mechanism which, when an electric impulse is received, causes the scriber to "jump" causing a tick mark along the line (on the paper). One set of tick marks are uniformly spaced (hopefully because of a uniform rotation of the drum) and represent the time signal from the chronometer or telegraph. The intermediate ticks represent the time that the astro event was recorded (representing the observer's perception when the star crossed the vertical wire). After the conclusion of the observations, the paper on the drum was unrolled, and the distance between successive tick marks was carefully scaled to discern the precise time. This procedure provided time to two orders of magnitude better than the "eye-ear" method.

The procedure was to attach the chronograph to the telegraph. The time signal was transmitted from the observer and imprinted on the drum. At the same time a second circuit from the observer sent the "event" signals for imprint on the drum.

Another improvement addressed in this era was astronomic latitude determination. Peder (Peter) Horrrebow (14 May 1679 - 15 April 1764), was a Danish astronomer. In about 1735 he developed the method of determining astronomic latitude by observing a pair of stars transiting the meridian at equal (or nearly equal) zenith distances north and south of the instrument's zenith. The method was mostly forgotten until is was independently developed by the American, Captain Andrew Talcott (27 April 1797 - 22 April 1883) in about 1832 or 1833. Talcott employed the procedure on the survey of the Michigan-Ohio land boundary. Lt. Thomas Jefferson Lee, Army Topographic Engineer, and civilian assistant Robert H. Fauntleroy first employed the telegraphic technique in 1846. The serious drawback to the procedure was not in the field observations, but the poor quality of the stars' catalogue positional data (declination). In 1848, Captain Lee joined forces with Professor Bartlett (at West Point) to employ the Academy's mural circle to improve the stars' positional information (right ascension and declination).

From 1845 until the end of the decade, Bache and his assistants realized that the geodetic community required an accurate longitude from which time signals were generated to produce accurate longitudes in the triangulation network. Bache initiated a program of observing and computing longitudes from moon occulations of the stars in the Pleiades (RA 3 h 47 m 24 s ; decl. + 24 o 07′) (also called the Seven Sisters). Bache and the Coast Survey instituted a trans-Atlantic transport of chronometers to determine the differences in longitude between the Harvard Observatory (Cambridge, Massachusetts) and several European observatories. Assistant

Sears Cook Walker addressed the problem, and recommend application of "Gauss's technique of 'least squares'" to determine the most probable value. In 1845, the difference was 4 h 44 m 30.69 s. In 1848, the astronomical observations produced the value of 4 h 44 m 30 s . The difference along the parallel at the Cambridge Laboratory is approximately 500 meters (1,640 feet, 0.31 mile). The problem would be addressed throughout the 1850's, but would only be resolved when the trans-Atlantic cable was constructed and a direct time transfer was possible. In 1897, the adopted difference in longitude was 4 h 44 m 31.046 s, which was about midway between the earlier determinations.

At the time of Hassler's death, the Congressional appropriation was $100,000. In 1845, Bache requested $111,000. His political savy was very apparent when studying the various reports defending and detailing future ramifications if funding was delayed or reduced

Bache was very active in the field operations, measuring base lines, and observing triangulation. He did not shun the administrative duties and responsibilities of being administrator or superintendent of the Coast Survey and the Office of Weights and Measures. In the budget year 1846-1847, he over spent the budget of $145,000 by $775! This is even more remarkable, because the Coast Survey had just procured steam vessels, but had little or no knowledge of annual operational costs.

As 1849 began, Bache was faced with a new executive administration, the expansion of responsibilities with the annexation of Texas, California and the Oregon Territory (as Oregon and Washington were known) coastal waters, and another Congressional attempt to dismantle the Coast Survey.

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