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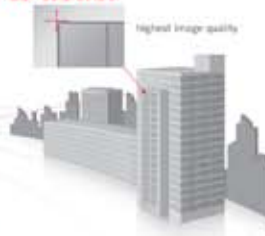
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On The Cover

MAP OF THE SOURCES
OF THE SNAKE RIVER
FROM SURVEYS AND
OBSERVATIONS OF THE
SNAKE RIVER EXPEDITION

CONTENTS

Page 3 • **PRESIDENT'S MESSAGE**

Page 4 • **USE H, NOT Z**
By: Dave Doyle

Page 5 • **WHY WFPS?**
By: Paul Reid, PLS

Page 7 • **GEODETIC SURVEYING: PART IV**
AGE OF ENLIGHTENMENT - PART 1
By: Herbert W. Stoughton, PhD, PELS, CP

Page 11 • **MAPMAKER**
FERDINAND VANDIVEER HAYDEN'S YELLOWSTONE
EXPEDITIONS OF 1871 AND 1872
By: Jim Houston
Photography By: William Henry Jackson

Page 21 • **ANNOUNCEMENTS**

2012 PLSW SUSTAINING MEMBERS

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- Richard Monsen - Monsen Engineering
- Bryan Baker - Frontier Precision Inc.
- Chris Farnsworth - RDO Integrated Controls

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For more information please contact Pete Hutchison or Jack Studley.

PLSW (Professional Land Surveyors of Wyoming) 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).

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PRESIDENT'S MESSAGE



Fellow PLSW Members,

The cooler evenings are fair warning fall is upon all of us. Looking at the current work load I pray we can each complete the 2013 construction season prior to snow fall, unfortunately several little projects seem to be dragging on personally. After learning of the tragedy in Colorado, I pray their fall will be mild and provide enough time for flood victims to clean up and rebuild prior to onset of winter and any snow accumulation.

The August Board of Directors meeting was held September 7, 2013 allowing for better attendance. Cotton Jones was directed to finalize the PLSW Memorandum of Understanding (MOU) with the NSPS. Cotton will deliver the finalized papers at the next NSPS meeting in November.

In the last news letter I mentioned we were finalizing changes to the PLSW web page. Unfortunately, we still are searching to improve the web page adding to the recent improvements. Mark Rehwaldt was asked to begin the quest to hire a professional firm to assist and maintain the web page. We hear your voices asking for an informative and useful web page, I am hopeful the web page will continue to grow and be a useful tool for each of us.

Mark your calendar, Fall Tech will be held in Casper November 7th and 8th at the Ramkota.

Respectfully,

Cevin C. Imus, P.L.S., President
Professional Land Surveyors of Wyoming

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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 November 1, 2013.

AGENDA

November 7 ST	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 8 ND	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 Best Western Ramkota Hotel, 800 N. Poplar Street, Casper, Wyoming.
Rate: \$70.99 per night. Telephone: 307-266-6000.

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

NSPS MAP/PLAT COMPETITION

The Wyoming Land Surveyors NSPS Map/Plat Design Competition will be held in conjunction with the seminar. Send your entries to Bill Fehringer or bring them to the seminar.

Larry Phipps, P.L.S. of Land Surveyors Workshops

Licensed surveyor since 1987, Larry has more than two decades of experience as the owner operator of Phipps Surveying. Larry also has held leadership positions in many community organizations. Also, Larry has taught other surveyors all around the country. He has become a regular featured trainer at the ACSM National Convention, having taught surveying related topics at 7 consecutive conventions. Larry has taught in more than 30 states and is a regular contributing author for POB Magazine.

The Seven Deadly Sins of Surveying

What things do we as surveyors commonly do that subject us to liability? This class takes a detailed look at seven common mistakes and suggests specific techniques to reduce or eliminate liability. Think you don't have any problems? Think again.

Cha Cha Changes

Surveying is undergoing a radical change. Like it or not, the profession today is nothing like the profession was 30 years ago and nothing like it will be 20 years from now. One look at the demographics of the licensee will tell you that one can not escape these changes. The question then becomes, what will the future bring and what can I do today to position myself for that future. This class will focus on helping the attendee prepare for their future in the profession.

Ethics for Land Surveyors

Ethics classes have become one of those dull boring tasks that the board rules make us endure every so often. Mostly, they suck. Not this class. In this class the attendees are expected to participate and give their own opinions but those opinions better be backed with logic and a foundation in the rules. Finally, an Ethics class where the student might learn something.

USE H, NOT Z

By Dave Doyle



During recent correspondence with a surveyor friend who was concerned about a positional difference he had observed at an old triangulation station, he sent me the following information:

N = 213674.3282 m,

E = 178633.4978 m,

Z = 6.9139 m.

Where the station is located is irrelevant.

This type of a coordinate description is very common. Whether the horizontal coordinates are State Plane, DTM, or some local coordinates is also irrelevant. What is relevant and wrong is his description of the height as "Z." I've heard surveyors express heights as Z countless times, and it's wrong.

You might counter that what's being described is a standard, three-dimensional Cartesian coordinate, and if this were a class in geometry you'd be right.

The general reference of Z as a height most often refers to the orthometric height value related to a vertical datum such as the National Geodetic Vertical Datum of 1929 (NGVD 29) or the North

SURVEYORS NEED TO
ENSURE THAT THEY
COMMUNICATE THE DATA
THEY ARE PROVIDING
ACCURATELY.

American Vertical Datum of 1988 (NAVD 88). In this particular case it was the Puerto Rico Vertical Datum of 2009 (PRVD 09). All of which are incorrect.

In standard geodetic texts, articles, and presentations, orthometric heights are referred to as H. For example, reference the excellent article, "Defining Surfaces" by professor Charles Ghilani in our July issue [Professional Surveyor Magazine]. As Dr. Ghilani notes,

there are other heights as well: ellipsoid heights referenced as h and geoid heights as N. Nowhere are heights referenced as Z.

In geodesy, Z as a coordinate reference is reserved for the value of a point on the surface of the Earth directly north or south of the plane of the Equator as part of its Earth-Centered Earth Fixed three-dimensional coordinates. The point referenced above would have a Z value of 1,953,823.627 m.

With the incredible technology of GNSS, the capacity for almost anyone to determine his or her three-dimensional position anywhere on the Earth is fairly trivial, yet we still see far too many instances of supposedly high-accuracy data sets that don't match each other. The reasons vary, but one is improper data element identification - metadata.

As leaders in the geospatial community, surveyors need to ensure that they communicate the data they are providing accurately. One very simple way to do this is to stop referring to orthometric heights as Z. If you really need a letter, use H - that's what it is.

-Dave

Dave Doyle is a contributing editor at Professional Surveyor Magazine. This article is reprinted with permission from the August 2013 issue of that publication.

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Why WFPS?

By Paul Reid, PLS
Wyoming WFPS Delegate

At the last PLSW Board of Directors Meeting (4 May 2013) and after discussion of NSPS affiliation, the question was brought up if there was even a need for "WESTFED", i.e. the Western Federation of Professional Surveyors organization. The following is my attempt to answer the question.

A Brief History of its Creation and Purpose:

It has been said that necessity is the mother of invention, and that is certainly applicable to the federation. It was conceived by an impromptu group of individual survey practitioners at the Western conference of Professional Land Surveyors in March 1979 at the Sahara Tahoe, Lake Tahoe, Nevada. The principal topic at the conference in formal meetings, as well as in the general undertone between meetings, was the relationship between the American Congress On Surveying & Mapping and the individual surveyor. Many surveyors at the time felt that the relationship was inadequate and deteriorating. In an attempt to halt the deterioration, and to rebuild a strong national organization, a steering committee was established to investigate the formation of a permanent western states organization which could present a unified voice to the national society. This steering committee was comprised of two delegates from each state in attendance at the conference. The prime objective of the committee was the formation of a cohesive regional group which could provide input to the American Congress on Surveying Mapping during its proposed reorganization and restructuring. The full purpose of the Western Federation as set forth in a resolution adopted at said conference was to work together to promote professional survey practice in the west; to support the efforts of the American Congress in its reorganization; and to assist in those efforts.

In order to accomplish the purpose, the Western Federation of Professional Land Surveyors (WFPLS) was structured to consist of two delegates from each western state including: Alaska, Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington and Wyoming.

The first official meeting of WFPLS convened at the MGM Grand Hotel in Reno, Nevada, on January 12, 1980, where the Articles of Incorporation were reviewed and adopted. Pursuant thereto, the first election of officers was held.

Much of the foregoing text was taken from: Robert D Cray, Immediate Past Chairman's Report to WFPLS, April 25, 1982.

As you can see from the above, the scenario was set for WESTFED to prod and promote the western influence of professional surveyors on A.C.S.M. Even so, WESTFED continued to support A.C.S.M. as the national representative of the professional surveyor. So as bittersweet as it was, WESTFED recognized the need for a national society, but one that would be more supportive of the grass roots surveyor.

In October 1987 the Western Federation of Professional Land Surveyors (WFPLS) changed its name to the Western Federation of Professional Surveyors (WFPS). The Articles of Incorporation were reviewed and The Federation vowed to continue to support and foster those purposes as put forth in the Articles of Incorporation, to wit:

- ☐ *Improve the national, regional and state image of the professional Land Surveyor*
- ☐ *Conduct a public relations program to increase public awareness of the professional Land Surveyor and his/her services*
- ☐ *Maintain active legislative involvement at the national and state level and providing regional coordination and assistance in legislative matters*
- ☐ *Provide regional communication by soliciting information from each member state organization and communicating said information to all members*
- ☐ *Develop and maintain recommendations for professional registration requirements*
- ☐ *Develop and maintain standards of practice for the profession which may serve as a guide for development of state manuals for standards of practice*
- ☐ *Develop programs which will provide professional development activities*
- ☐ *Cooperate with other regional, national and international professional societies dedicated to serving the land surveying profession.*

In 1992 Hawaii was added as the 13th WFPS state.

Today, delegates meet three times a year and WFPS continues to foster the dissemination of information among the thirteen western states and actively influences governmental affairs and legislation in such a manner as to benefit both the public and the surveying profession.

What has WFPS done?

- Co-Authoring a Board of Registration Licensing Handbook
- Sponsored or Co-Sponsored Biennial conferences in the thirteen WESTFED states from 1979 to 2013
- Donated \$10,000 to ACSM during the office building budget crisis in October, 1999
- Hired a legislative consultant for WFPS States
- Joined in the USFS Procurement Lawsuit leading up to acceptance of the Brook's Bill in federal procurement for survey related work
- Sponsored NMSU/IA Survey Technician Program
- Provided complimentary PLSS workshops to Hawaii for their 2010 conference, to aid their LSI test candidates who had no exposure to the PLSS during their training
- Beginning in 1992 to present, WFPS has awarded a total of over \$75,000 in scholarships to students enrolled in a four year college program, working toward a degree in land surveying.
- Working with NCEES matching funds and the thirteen WESTFED states, we have expanded a successful program (TWIST) from the state of Washington that provides surveying related knowledge to elementary school teachers who will inspire young students to consider a surveying related career. This year alone WESTFED will be sponsoring about 24 teachers with a total program budget of up to \$50,000. This is a full week long program to be held this year in Clark College in Vancouver, Washington. Teachers will leave at the end of the week with a handheld GPS receiver and ESRI software, along with the knowledge to put their new tools to work in the classroom.
- Sponsored various western state teams to attend the NSPS student survey competition.
- Provided monetary support for the David Thompson canoe trip.

- Provided support in many and various ways to colleges in the WESTFED states that offer a four year degree program in land surveying.
- Lobbied to change key provisions in the Surveying Model Law
- Provided testimony and support to various WESTFED states during periods of proposed change regarding statute and rules overseen by various western states' Boards of Registration
- Reviewed and commented on NCEES test questions and testing methodology.
- Provided various letters of support and offers of assistance to NSPS over the years for many of their projects and battles, i.e.: railroad abandonment, NAFTA, NCEES Model LAW, ABET (Civil Engineering review of Surveying programs), Brooks Bill, etc.
- Provided information, support and templates for success to member states with legislative endeavors including but not limited to: definition of surveying, monument preservation, right of entry, statutes of repose and limitation, land use control, removing any reference to "engineering surveys" from the Model Law, Height Mod, etc.

WFPS today:

At the last WFPS Board of Directors meeting NSPS President Lamar Evers was present and was questioned on many items by members of the board. He reported that over 50% of states have signed the 100% Membership MOU. Each state has modified the MOU slightly.

The Florida Association, who has had problems with anti-trust lawsuits in the past, will provide their members an opt out. WFPS Delegates voiced concern, should NSPS be raising dues above \$40 in the future. Lamar responded that no association can guarantee they won't raise dues and that it is based

on the cost of doing business. WFPS Delegates asked how NSPS can help promote membership within the state. Some states that have instituted 100% membership have seen a drop off in membership. Lamar indicated that it is up to the states to promote membership. It was suggested that NSPS put together a brochure on their member benefits and provide that to the states for their use in promoting membership and explaining the value of the additional \$40. WFPS asked how NSPS will be structured. It has been reported that one of the reasons for the split from ACSM was that NSPS had a majority of the membership but only one vote. Will each state that participated in the 100% membership program receive proportional representation? How will states that do not participate in the 100% membership be represented? Lamar reported that not all details are worked out yet but most likely the Governors and Area Directors will be phased out and there will be one Director from each state participating in the 100% membership program and Directors at Large will represent states not participating. Lamar reported that NSPS will no longer be selling publications and they are phasing out their inventory. They also will no longer be selling logo merchandise. Instead, a logo will be on file at places like Lands End for members to order directly. Lamar stated that NSPS has two new contracts. One, with John Palatiello for legislative programs and the other with Flat Dog Media (Professional Surveyor magazine) for public relations (newsletters, social media, blog). Lamar made it quite clear that NSPS is going to be run more efficiently as a business and cost minded. WFPS discussed formalizing their relationship with NSPS with a MOU. Lamar was to send WFPS Secretary Nancy

(Continued on Page 21)

Geodetic Surveying: Part IV

Age of Enlightenment -Part 1

In the last decades of the eighteenth century the geodetic survey operations were a mix-mash of older procedures and transition to the survey operations, instrumentation, theory, computations, and adjustments, currently employed.

One of the first methods was proposed by Adrien-Marie Legendre during the survey operations with General Roy and his personnel in the cross English Channel triangulation between Dover and Dunkirk. In the early operations of triangulation, the English geodesists computed the triangles by the chord method. Legendre demonstrated to the English and French geodesists working on the triangulation to connect the Paris and Greenwich Observatories a simple method to reduce the observed angles from spheroidal angles to plane angles. The procedure is known as Legendre's Theorem (1788).

Legendre was educated at the *College Mazarin* in Paris. He taught at *École Militaire*, Paris and *École Normale*. He was associated with the Bureau des longitudes. It was in an appendix of *Nouvelles Méthodes pour la Détermination des Orbites des Comètes* (1806) that the method of least squares appeared. This writing reinforces Legendre's claim for developing least squares over his contemporary Gauss.

Legendre's theorem is *not* a theorem of pure mathematics by a *theorem of applied mathematics*. Historically, students of spherical trigonometry and geometrical geodesy have studied this theorem. In spherical trigonometry, the sum of the interior angles of a spherical triangle range between 180° to 540° , while in plane trigonometry the sum of the interior angles of a plane triangle exactly equals 180° . If a plane triangle and a spherical triangle have sides whose lengths are equal, then the excess of the sum of the internal angles of the spherical triangle over 180° is called the *spherical excess*. One geodetic textbook states the problem: "If one-third the spherical excess of the triangle is deducted (subtracted) from each angle, the triangle can be solved, in terms of the linear lengths of the sides, by the ordinary rules of plane trigonometry." Legendre commenced

his proof by stating that the surface area of the spherical triangle is extremely small compared to the total surface area of the sphere. He does not quantify the magnitude of "extremely small". He continues by stating that the linear lengths of the sides of the plane triangle equal the arc lengths of the corresponding spherical triangle. However, no where is it stated that the plane triangle is either secant or tangent to the sphere. The magnitude of the spherical excess is a function of the area of the spherical triangle and the plane triangle. The resulting plane triangle is sometimes called a *Legendre triangle*. As a rule-of-thumb, for approximately every seventy-five square miles equates to about one arc second of spherical excess.

The last decades of the eighteenth century and the first half of the nineteenth century saw numerous countries initiate national mapping programs. These included, but were not limited to, the United States of America, several German states, Austria, Spain, Cape Colony, Russia, and India to name a few.

One of the most significant endeavors would be the Great Trigonometrical Survey (India). The first director was Colonel William Lambton (c.1753 - 1823). Lambton was born in North Riding of Yorkshire. His early ability in mathematics earned him a place in grammar school, and in 1781, a posting in an Infantry Regiment. He promptly was sent to America to fight in the American Revolution, and was taken prisoner at Yorktown, Virginia. After release he was assigned to surveying and mapping work in New Brunswick. He remained in Canada until 1793, and was promoted to lieutenant. It was during this tenure that Lambton became acquainted with geodesy, triangulation, and the work of General Roy, Picard, the Cassinis, et al. In 1796, Lambton was posted to India, and served under Colonel Arthur Wesley (Wellesley) (1769 - 1852) who would later be known as the Duke of Wellington. It was during a war between the British and Tipu Sultan, known as the "Tiger of Mysore", Lambton proposed a detailed mapping effort to support British forces. As part of this effort triangulation

would be employed. India was a perfect location to expand and improve the knowledge of the size and shape of the earth's ellipsoid. Previously, all the triangulations had been executed in Europe, South Africa, and South America. The latitudinal extent of India was midway between the latitudes of the earlier surveys. Lambton's approach to the project appealed to Wellesley. Lambton stressed the value of ascertaining the correct positions of principal geographical points based upon correct mathematical principles. Lambton's triangulation would provide the reference (frame work or skeleton) upon which local mapping projects could be referenced. Colonel Colin Mackenzie, who was directing the local mapping; Colonel Arthur Wellesley; and Governor-General Richard Wellesley endorsed the project. In 1800, the survey was approved.

Lambton found a theodolite very similar to the "great theodolite" (built by Jesse Ramsden) which had been built by William Cary, an English instrument maker. The theodolite weighed nearly one thousand pounds. Today, the instrument is displayed at the Survey of India offices in Dehra Dun. Lambton also located a steel chain and a large zenith sector. Lambton subsequently acquired a second chain which was used for comparison. Lambton recognized that the intense heat (80° - 120° F.) affected the length of the chain. Therefore, he applied a correction of 0.007452 inch per degree Fahrenheit for one hundred feet. This equates to a linear coefficient of expansion 0.0000 0618 ft/ft/ $^{\circ}$ F. The currently accepted value is 0.0000 0645 ft/ft/ $^{\circ}$ F. On 10 April 1802, Lambton commenced the Great Trigonometrical Survey (of India). The twelve kilometer baseline (near Madras) required 57 days to collect four hundred measurements.

From the start of the survey, Colonel Lambton was assisted by Henry Kater (16 April 1777 - 26 April 1835). In 1808, Lieutenant Kater returned to England in very poor health, and was posted at the *Royal Military College* at Sandhurst. Here he reviewed the merits of Cassegrainian and Georgorian telescopes; invented the Kater's pendulum for precise gravity measurements; invented the floating collimator (for astronomy); studied the British and Russian standards of length and mass; developed the prismatic compass (patented by Charles Schmalcalder); and studied

compass needles. His contributions to gravimetry were far reaching.

Colonel Lambton was meticulous in his work. When the triangulated length computed through the triangles between Bangalor and Coimbatore was compared to the next baseline, the discrepancy was 0.633 foot. Until 1818, the Great Trigonometrical Survey was under the auspices of the Madra government. At that time the survey had extended outside the Madra government's domain, and the survey was transferred to the supreme government at Calcutta and officially named the *Great Trigonometrical Survey of India*. At the same time George Everest (4 July 1790 - 1 December 1866) joined the Survey on Boxing Day 1818 (26 December 1818), and soon after assumed the directorship of the triangulation. In 1830 Everest was appointed Surveyor General of India.

A month after Everest's arrival, Lambton, in very poor health, traveled to his home in Hyderabad, and rarely participated in any additional field work. Thus, Everest took over the field operations. Colonel Lambton directed operations, performed calculations, and lobbied in Calcutta for additional surveys and financing. By 1820, the Great Trigonometrical Survey had received recognition in the scientific societies of Europe.

Within two years, Everest was nearly a semi-invalid due to the numerous diseases which ravaged the India subcontinent. He spent some time at Cape Colony recuperating. Everest's time at the Cape Colony was spent reviewing early triangulation performed near the mid eighteenth century. He prepared a report which will be discussed later. In 1825, Everest returned to England on sick leave, which would last until 1830. During this period he acquired new and improved survey instrumentation. He also visited Colonel Colby, in Ireland, and witnessed the triangulation operations there. Everest purchased the Colby compensation base apparatus, and employed it in India. The first baseline was observed along the Barrackpur Road near Calcutta. The nearly six mile baseline was observed in November and December 1831 and January 1832. There were 539 separate measurements. In 1833, Everest shipped his instruments and office from Calcutta to Hathipaon. After heated discussions with the government about this relocation, the

headquarters were relocated in Dehra Dun, a short distance from Hathipaon. Dehra Dun remains the Survey of India headquarters to this day. Everest continued the work on the "Great Arc" amid numerous attacks of illness, which lasted for months. From 1841 to 1843 Everest completed his calculations. In 1843, Everest considered the Great Arc completed. He retired and returned to England. The Great Arc alone extended 2,400 kilometers (approximately 1,500 miles). The final results included a new mathematical figure of the earth. Guy Bomford lists the values for the Everest ellipsoid as: equatorial radius 6,377,276 m.; polar radius 6,356,075 m.; and compression as 1 :300.80.

During the first eleven years of the Great Trigonometrical Survey, the India subcontinent was relatively peaceful compared to Europe. The post Napoleonic Europe witnessed an increased demand for greatly improved maps for military and economic endeavors. It was well understood and accepted that accurate mapping required accurate survey control (triangulation).

Between 1818 and 1832 most of the efforts of Carl Friedrich Gauss (30 April 1777 - 23 February 1855) directed the surveying and mapping of the Electorate of Hannover. Gauss was a child prodigy in mathematics. He attended the *Collegium Carolinum* (1792 - 1795) and the *University of Göttingen* (1795 - 1798). Dr. Gauss was appointed Professor of Astronomy and Director of the Göttingen Observatory in 1807, which positions he retained until his death. Although Gauss published his first work on least squares in 1809, three years after Legendre, he claimed to have used the method in his doctoral research in 1795. Gauss personally oversaw the geodetic field work and computations. Although Gauss (1809) and Legendre (1806) independently "discovered" the method of least squares, each first applied the theory to celestial orbit determinations. Gauss's efforts included invention of the heliotrope, and he developed methods for analyzing geodetic observations and data. Peter Pesic (*St. John's College*; Santa Fe, New Mexico) calls Gauss the father of modern geodesy.

Although all the nuances are not clear, Dr. Gauss's *General Investigations of Curved Surfaces* (1827) begins his work with a detailed comparison between spherical geometry and the actual curved

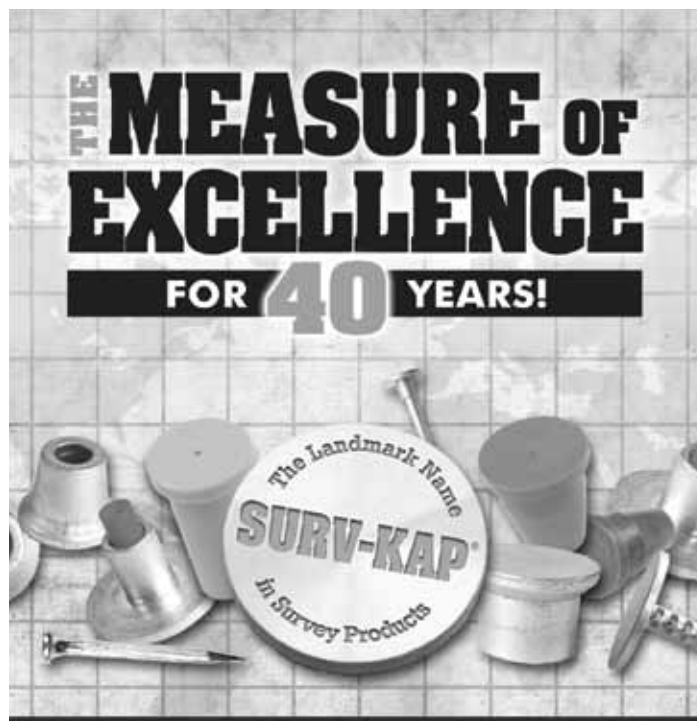
surface being mapped. In his studies, Gauss had to determine the degree of the ellipsoidal earth's double curvature was observable and could affect surveys. The result was the theorem; "If a curved surface is developed upon any other surface whatever, the measure of curvature in each point remains unchanged." Gauss also developed the work of Leonhard Euler (1707 - 1783) on *geodesics*, which are the shortest lines on a curved surface. This means that the cartesian grid of orthogonal lines on the plane can be generalized to grids of geodesics on a curved surfaces. One source reported that Gauss personally computed and adjusted over one thousand points. In *General Investigations of Curved Surfaces*, Gauss demonstrated that Legendre's theorem was in complete agreement with his investigations.

Friedrich Wilhelm Bessel (22 July 1784 - 17 March 1846) was a student of Gauss (doctoral studies) and a noted mathematician, astronomer, and geodesist. Bessel was equally competent in all three subjects. He was an assistant at the *Lilienthal Observatory* where he computed refinements for the orbit of Halley's Comet and precise positions for James Bradley (late Astronomer Royal at the *Greenwich Observatory*) star observations for 3,222 stars. At the age of 25, Bessel was appointed director of the *Königsberg Observatory* where he determined improved positions for over 50,000 stars and tables for atmospheric refraction based on Bradley's work. In 1838, Bessel was the first person to use stellar parallax to compute interstellar distances (today, it is estimated that Bessel's value is in error by only 8.8 percent). In the second decade of the nineteenth century, he developed Bessel functions. His study and analysis of errors in theodolites is considered the definitive work on the subject. Bessel also computed the size and flattening of the earth from many of the observations reported herein, and published a number of papers on reducing geodetic data and geodetic data adjustment (least squares).

Mean while, the western hemisphere (except for Peru) was not the setting of earth arc measurement in the eighteenth century. Since the founding of the colonies of Pennsylvania and Maryland, the proprietors [William Penn (Pennsylvania and Delaware) and Lord Calvert (Maryland)] had disagreed about their common colonial land

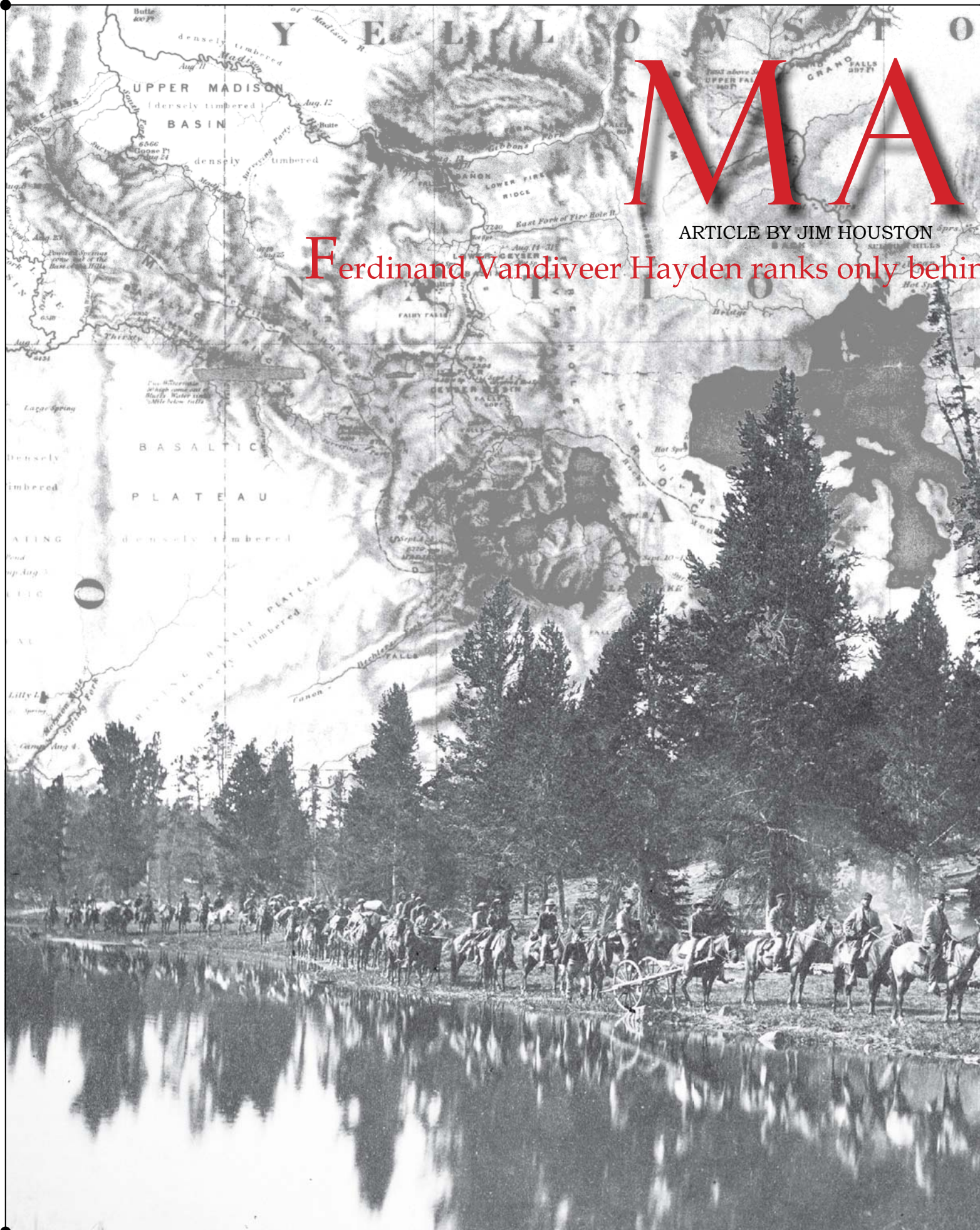
boundaries. To settle the dispute, Charles Mason (April 1728 - 5 October 1786) and Jeremiah Dixon (27 July 1733 - 22 January 1779) were sent from England to layoff and monument the boundaries. Besides executing the boundary surveys, Mason and Dixon were commissioned by the *Royal Society of London* to measure an arc of the meridian in Maryland and Pennsylvania. The surveys were executed between 1763 and 1768. Mason and Dixon measured a north-south survey line by traverse, and observed the latitudes at the termini. The results were reported in the *Philosophical Transactions of the Royal Society of London*, but are only a footnote in the history of determining the size and shape of the earth.

The age of enlightenment in geodetic surveying was just beginning. There would be many discoveries and developments in mathematics, geodesy, least squares, astronomy, and statistics, as well as the launching of several major geodetic survey campaigns for the remainder of the nineteenth century.



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N E PMAKER

PHOTOGRAPHY BY WILLIAM HENRY JACKSON, COURTESY OF THE DENVER PUBLIC LIBRARY

and Lewis and Clark as an icon of western United States exploration.

This ranking may be debated; however, Hayden's credit in the establishment of Yellowstone National Park certainly justifies a high place in western history. From 1853 through 1879, his career affected western America. The only interruption in his career of exploration was a stint as a surgeon for Union forces during the Civil War.

This long, inspired career involved many noteworthy

episodes, which may be studied in his biography. The purpose of this article, however, is to highlight events concerning the Yellowstone region, especially the expeditions of 1871 and 1872.

Hayden's experience in the Yellowstone vicinity began on the lower Yellowstone River in 1853 when he was a member of an exploring party led by General G.K. Warren and guided by Jim Bridger. During 1859-60, he was again with a party guided by Jim Bridger. Captain William Reynolds led the group. Hayden was paid \$120 a month and was issued a revolver, two blankets, an overcoat, one pair of boots, a knapsack, two pair of trousers, a canteen, and a knife. A friend loaned Hayden a shotgun.

After spending the winter on the upper North Fork of the Platte River about 100 miles above Fort Laramie, the party embarked on what came to be a circuitous failure. Despite the guidance of Bridger, who certainly was familiar with the country, they floundered in spring snow, crossing from the Wind River drainage into the Snake River drainage over a saddle Reynolds named Union Pass. Deep snow continued to plague them as they traveled down the Gros Ventre into Jackson Hole.

Somehow crossing the Teton Range, they coursed down through Pierre's Hole, north into the Henry's Lake area, and across Reynolds's Pass to the Madison River.

Even with Jim Bridger to lead the way, they failed to reach the headwaters of the Madison or the Yellowstone. This dysfunctional party of explorers then took a less demanding route and went down the Madison and subsequently to Fort Union, near the confluence of the Missouri and Yellowstone

A part of the 1871 Hayden expedition on the shore of Mirror Lake headed toward what would later be known as the Lamar River on the eastern edge of Yellowstone Park. (Courtesy of the Denver Public Library)



ivers. The expedition of 1860 was a failure, but Hayden did make one noteworthy discovery. During June, 1860, while in the Wind River Mountains, he shot and described the first snowshoe hare ever reported in the United States.

1871 EXPEDITION

Congress appropriated \$40,000 for Hayden's 1871 Yellowstone expedition. Thirty-two men accompanied Hayden. James Stevenson served as managing director. Notables among the personnel were William Henry Jackson, the party's photographer; Henry Wood Elliot, official artist; G.N. Allen, botanist; and painter Thomas Moran, who was officially designated as a "guest." In addition to the scientists, there were three hunters, five cooks/waiters, seven wranglers, and two Army officers serving as a military escort. Equipment and supplies were obtained at Fort D.A. Russell, the present-day Warren Air Force Base. Horses, mules, and wagons were loaded on Union Pacific freight cars accompanied by expedition members in a passenger car. Railroad officials granted free passes for both personnel and equipment.

Arriving in Ogden, Utah Territory, the party was organized and in a few days departed for Fort Hall on June 8, 1871. From there, they followed the stage road to Virginia City, Montana Territory, which they reached in July, then went east, reaching Fort Ellis on July 10. After resupplying, they traveled up the Yellowstone River to the Bottler Ranch near present Gardiner, Montana. There they made a permanent camp and left their wagons.

Traveling with horses and

mules, the party surveyed their way through Mammoth Hot Springs and onto the Yellowstone Plateau. They reached Tower Falls on July 25. From Tower Falls, they went to the falls of the Yellowstone River. On July 28, they were at Yellowstone Lake; the lake was mapped both from shore and from a small boat they built and named Anna. This was the first boat on Yellowstone Lake. They reported a maximum depth of 300 feet in the lake.

While Jackson photographed the area, both artists, Moran and Elliot, made sketches for the illustrations needed for future reports. Turning back north, the expedition traveled through the Pelican Creek drainage and Lamar Valley before returning to the Bottler Ranch on August 28 on their way back to Fort Ellis.

Coming back, they followed the Jefferson River, crossed the Continental Divide to the Snake River, made a short stop at Fort Hall, then rode to Evanston, where the expedition disbanded on September 29 and took passage to their homes on the Union Pacific Railroad.

Hayden was busy during the winter of 1871-72. He compiled comprehensive reports on the expedition and wrote popular articles for Scribner's Monthly Magazine, the Helena Daily Herald, New York Times, Boston Advisor, Omaha Herald, Sacramento Bee, and Leslie's Illustrated. Hayden made presentations at every opportunity. Jackson's negatives were lithographed and provided visual effects for Hayden's reports. Thomas Moran's sketches resulted in the famous Grand Canyon of the Yellowstone painting which was used by Hayden in his presentations

to Congress before being sold to Congress for \$10,000. Henry Elliott's sketches also illustrated Hayden's reports.

Hayden was not alone in promoting the Yellowstone area as a national park. Civil War Brevet General Henry Washburn led an expedition into the Yellowstone area in 1870. This expedition was partially subsidized by Jay Cook and his Northern Pacific Railroad. A member of this party was Nathaniel Langford who later lectured in Washington, D.C., promoting establishment of a Yellowstone National Park. Langford subsequently was appointed as the first superintendent of the park.

Congress approved the Yellowstone Park Act on December 18, 1871, and President Grant signed the bill on March 1, 1872. Hayden was not one to rest on his laurels. Even before this significant victory, he was already preparing for a bigger and better expedition for the summer of 1872.

1872 EXPEDITION

The extensive promotion efforts by Hayden, Langford, and Cook did more than convince Congress to establish the park. On the tide of enthusiasm for Yellowstone that followed, Congress gave Hayden \$75,000 for the 1872 expedition.

Hayden recognized mistakes had been made the previous year, which he intended to correct. He also wanted to survey more of the newly established national park. To accomplish this, he recruited a large party of scientists, specialists, packers, and hunters.

The official report submitted by Hayden lists thirty-six members, the authoritative history of the park, Yellowstone Story by Aubrey L. Haines, lists sixty-four. Whatever the

actual number, Hayden divided the party into two groups, the south party and the north party. Hayden led the northern group, and his assistant from the 1871 expedition, James Stevenson, headed up the south group.

The Hayden group started at Fort Ellis on July 20 and proceeded into the Gallatin and Yellowstone drainages, investigating landforms and geological deposits along the way. William Henry Holmes sketched the Devil's Slide on the Yellowstone River below Gardiner. Hayden described its volcanic origin and noted petrified trees in the general area.

August 1 found the expedition in the Clark's Fork drainage of the Yellowstone River, where silver mining was evident. Heading west, they followed what we now know as the Lamar Valley. William Blackmore, an English guest of Hayden's, caught over 100 trout ranging in size from twelve to fifteen inches in a few hours fishing on Slough Creek.

On August 24, the group camped on the upper Madison

River after having made a circle to Henry's Lake. Their course then went down the Madison and over into the Virginia City-Alder Gulch area, which had been a gold mining center since 1863. Hayden went north, apparently to satisfy an obligation to survey a strip of land lying between Yellowstone and the Northern Pacific Railroad.

James Stevenson's party, the south group, left Ogden on May 24. They numbered thirty, which included packers, cooks, and a hunter. Notable among this group was Nathaniel Langford who had been a member of the Washburn expedition in 1870. William Henry Jackson was again present to expose more glass plates. The crew was guided by Richard Leigh, mountain man and beaver trapper who was known as Beaver Dick.

From Ogden, Stevenson and his men followed the stage road to Fort Hall, arriving there on July 3. The survey of geological features apparently occupied most of June. The large wagon, which had carried most of their

equipment, was left at Fort Hall. They loaded pack mules and headed toward Pierre's Hole and the Teton peaks, reaching Pierre's Hole on July 21. Above Pierre's Hole, they established a permanent camp on July 23. A temporary camp was also made near the base of the Tetons and several members set out to climb the highest of these peaks. James Stevenson and Langford reported they had succeeded in reaching the summit. In honor of the survey director, they officially named this peak Mount Hayden.

Wildlife was abundant. A grizzly, a cow moose, and two moose calves were killed on West Teton Creek. Bighorn sheep sign was abundant on the Teton peaks. Three varieties of grouse were seen along the streams.

Plans to cross Teton Pass and descend into Jackson Hole were thwarted by deep snow. Instead they left their Teton camp on August 2 and traveled to the Henry's Fork of the Snake River. They bypassed the falls in the canyon of the Henry's Fork.

The Anna was built on the shore of Yellowstone Lake in 1871 to allow the survey team to take soundings and explore nearby islands. James Stevenson, survey manager, and Chester Dawes, one of the expedition's members, set sail here on an unusually calm day on the lake. (Photo courtesy of the Denver Public Library)





Joe Clark (left) and his assistant, remembered only as Jose (right), were the surveyor's chief hunters, supplying fresh game meat to the party, which consisted of thirty-six hungry civilians and a small army escort. The group kept track of its daily progress with a wheeled odometer (far right) pulled behind a horse. (Photo courtesy of the Denver Public Library)

On August 8, they reached Henry's Lake. At the Sawtelle Ranch, they found the owner and a helper named Wurtz harvesting native hay. Sawtelle told Stevenson that he had caught enough fish in Henry's Lake to justify packing them fifty miles to Virginia City for sale.

The survey party headed north across Tyghee Pass (now named Targhee) and into the Madison valley, then up the Firehole River into Yellowstone's Lower Geyser Basin.

Here, they found Hayden's party, which had come from Bozeman via the Yellowstone valley. James Stevenson took

the collections from both parties and started for Virginia City on August 17. His orders were to send the collections by stage, then rail to the Smithsonian Institution. After he had packed and shipped the specimens, he returned to the park, bringing provision for both parties. Hayden's party proceeded down the Madison River and out of the park to survey the strip of land between the park and Helena.

While awaiting Stevenson's return from Virginia City, a small group of seven, led by Frank Bradley, traveled to the falls of the Yellowstone and Yellowstone Lake. Bradley succeeded in

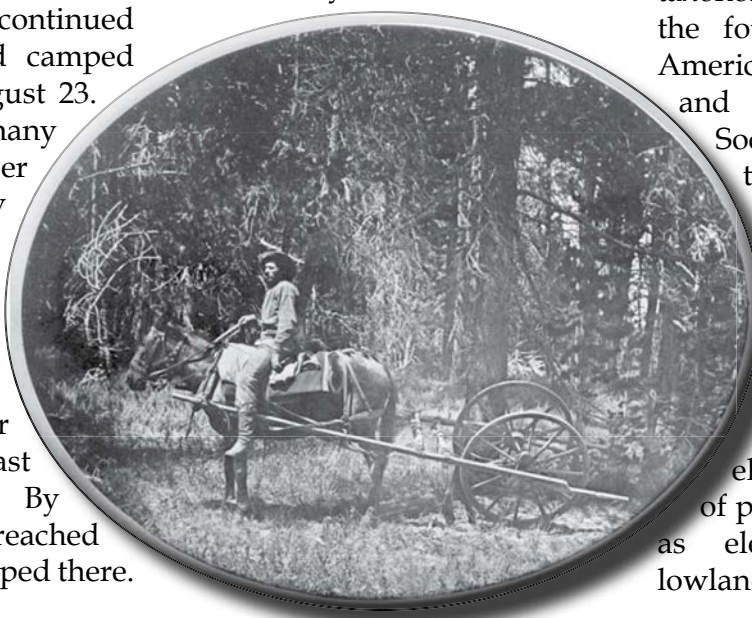


climbing down the west slope of the canyon to the foot of the lower falls. After he made it back to the rim, the group continued south to the lake and camped near the outlet on August 23.

The party described many geysers in both the upper and lower basins. Many were described in detail, including Old Faithful's regularity.

Stevenson rejoined his party on August 31, and on September 3, they started the last leg of their journey. By September 5, they had reached Shoshone Lake and camped there.

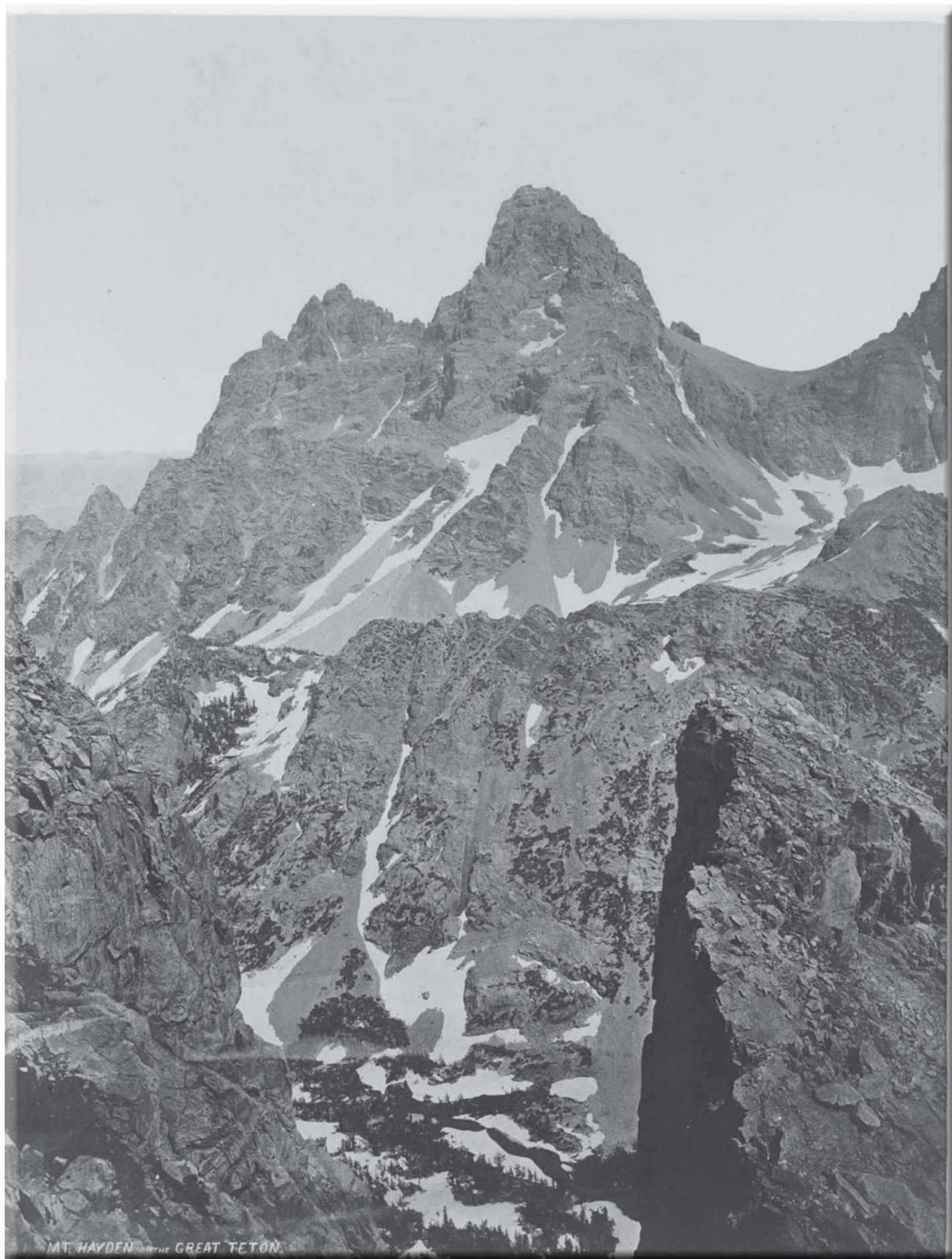
The geysers in this area were investigated and some of them named. They reached Lewis Lake



on September 11. Depths were recorded, probably using a raft; the deepest found at Lewis Lake was 108 feet. They named the lake in honor of Merriwether Lewis. As they had done throughout their survey, they measured the water temperatures of many geysers around the lake.

C. Hart Merriam, sixteen years old and the youngest member of the expedition, collected birds and mammals throughout the trip. He collected and skinned 313 birds. It was during this period that he collected snowshoe hares, all of which he identified as males. Miraculously, he reported that all five had mammary glands and were suckling young. This phenomenon was verified by another naturalist, Josiah Curtis. Hayden included records of Merriam's specimens in his 1873 official report titled *Geological Survey of the Territories*. A clipping from the January 11, 1883, copy of *Nature Magazine* referred to these hares. To quote the last sentence in the *Nature* clipping: "In the face of such testimony, disbelief would seem discourtesy."

Merriam went on to a stellar career as a zoologist and taxonomist. He was one of the founding members of the American Ornithologists' Union and National Geographic Society as well as director of the Division of Economic Ornithology and Mammalogy, forerunner of the U.S. Fish and Wildlife Service. Among his accomplishments were publishing the first concept of life zones, the elevation changes in species of plants, birds, and mammals as elevation increases from lowlands to timberline. He was



MT. HAYDEN on the GREAT TETON



known as a splitter, classifying many mammals and birds as subspecies according to minute physical characteristics. Many of the subspecies he established were subsequently lumped into broader classifications.

Stevenson's crew camped on the upper Snake River near the present south Yellowstone Park boundary. Beaver Dick led the survey party to the shore of Jackson Lake, where camp was established on September 24. Soundings of the lake found a maximum depth of 258 feet.

Exploring the base of the Teton Range, they found a small lake, which they named for their guide, Dick Leigh. They named another lake about a mile south for Leigh's wife, Jennie. Two more lakes to the south were also named: Taggart Lake was named in honor of William Taggart, a member of the party, and another small lake was named for a man known as Phelps, a hunter living in the area.

As winter approached, Stevenson's party traversed Jackson Hole, past the Hoback River junction with the Snake, then rode west, skirting the Wyoming Range, and the Greys and Salt rivers before heading to Fort Hall, arriving there on October 11.

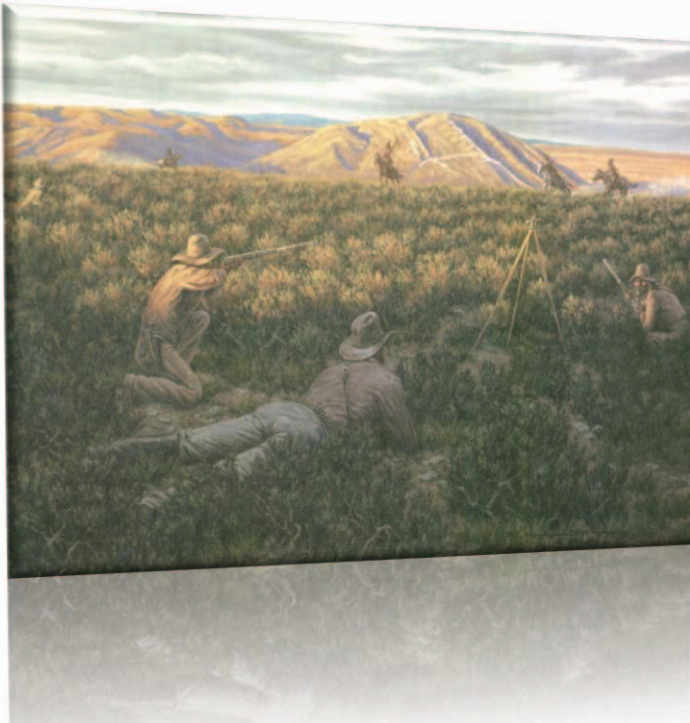
The southern 1872 Hayden Survey party included some members who were beginning illustrious careers. William Henry Jackson was to become most famous as a photographer of western scenery and railroads; John M. Coulter, who in 1872 collected more than 1,200 plant species, went on to a career in botany, writing several books and finally serving as president of Indiana University; and Clinton Hart Merriam made a mark in the discipline of zoology before establishing a career as the leader of the federal government's emerging wildlife conservation agency.

Survey members (above) pose at mealtime somewhere in Utah. Survey leader Hayden is in the center. The Grand Teton (opposing) was christened Mount Hayden by team members, but the name didn't stick. (Photo courtesy of the Denver Public Library)

Nearly a century and a half has passed since Hayden's successful efforts to establish the world's first national park. Mount Hayden is now Grand Teton. The honor of being first to reach the summit of the Grand has also been controversial. It is now theorized that the Hayden Party members reached the summit of a side peak and not the Grand itself. Ferdinand Hayden, however, should be honored for his contributions to the establishment of Yellowstone National Park and the naming of Hayden Valley, one of the park's outstanding features.

History buff Jim Houston spent his career with the Colorado Division of Wildlife before retiring to the Bozeman area.

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Responsible Chapter	First Call Date	Last Call Date	Publication Date
South Central Chapter	THANK YOU!! (SEE "MAPMAKER" IN THIS ISSUE)		
Southeast Chapter	December 1	December 15, 2013	January 1, 2014
Laramie Valley Chapter	March 1	March 15	April 1
Upper Platte Chapter	June 1	June 15	July 1
Southwest Chapter	September 1	September 15	October 1
Northeast Chapter	December 1	December 15, 2014	January 1, 2015

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ANNOUNCEMENTS

The Wyoming Engineering Society is soliciting applications for the 2013 President's Project of the Year Award. The award increases the public's recognition of engineering and surveying projects in Wyoming. The guidelines for submission of a project may be found at www.eng.uwyo.edu/societies/wes. Please keep the guidelines in mind during

this construction season as the projects progress and are completed so that all necessary documents and photos are compiled. Entries must be received in Laramie on or before Monday, January 6, 2014. It is encouraged that the guidelines and application form be reviewed to determine a project worthwhile for statewide recognition.

(Continued from Page 6)

Almanzan samples of MOUs that NSPS has with similar organizations.

In summary of Why WFPS, it was apparent from the last Board of Directors meeting, when NSPS President Lamar Evers stated that WFPS is a needed regional organization. The influence of WFPS on the national organization of ACSM/NSPS was noted by Lamar as good and necessary.

Presently WFPS recognizes that the landscape with western state surveyor organizations has changed dramatically over the years. With the advent of PDH/CE requirements, State associations are conducting their own state conventions with larger attendances and programs. Scholarship programs with auctions have enhanced the educational opportunities of students engaged in a surveying education in almost all of the WFPS states. With that said, the funds raised by hosting a biennial regional conference have dwindled. The struggle to find funds to keep WFPS afloat is the next big challenge of WFPS. As far as the necessity of WFPS it is unanimous among the delegates of the benefits WFPS has provided to the member states. Many of the objectives and purposes stated in the Articles of Incorporation still remain to this day. Most importantly is the dissemination of information among the member states and the influence it has had on governmental affairs and legislation that benefits both the public and the surveying profession.

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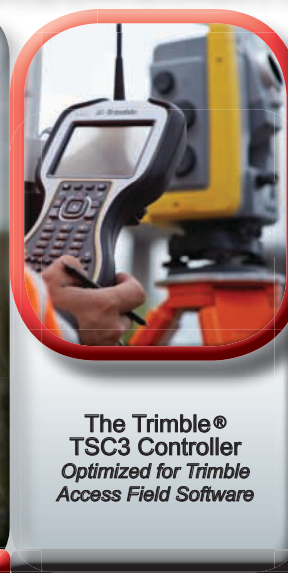
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