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LINES & POINTS

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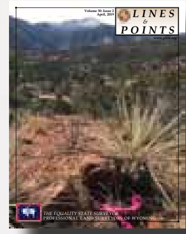
THE EQUALITY STATE SURVEYOR
PROFESSIONAL LAND SURVEYORS OF WYOMING

P.L.S.W.



On The Cover

Unknown Location
Photo by Anthony Whitlock

CONTENTS

Publications Committee

2019 PLSW SUSTAINING MEMBERS

- Jason Dysthe - Frontier Precision Inc.
- John Baffert - Surv-KAP, LLC
- Chris Farnsworth - RDO Integrated Controls
- Kelly Goff - Underground Consulting Solutions
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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).

PRESIDENT'S MESSAGE

It looks like winter has finally arrived, with March not giving any relief. At this point, double digits are beginning to feel tropical. It seems we surveyors are either wishing it would thaw out so we can survey, or wishing it would snow so things can finally calm down a bit.

The part of winter I enjoy most are the various opportunities for continuing education and the chance to socialize with fellow surveyors. Last month, I enjoyed seeing several of you at WES in Cheyenne. Those in attendance were rewarded with good courses, good company, and good discussion. There were several topics of note in the PLSW annual meeting. Special guest Karen Rogers, President of the Wyoming Geospatial Organization (WYGEO), introduced the idea of a joint conference between PLSW and WYGEO. This is an interesting idea that we look forward to discussing further. A pilot "augmented reality sandbox" (various video examples available online) is being built in the West Chapter area for use as an outreach tool to young people. If successful, there may be desire to have a few more in different regions across the state for use in outreach endeavors. The idea of having vendors at Fall Tech was also discussed, with hopes to try it out this fall. John Lee and Suzie Sparks modeled the new PLSW logo jackets, which looked great, so thanks go to the Southeast Chapter for organizing that.

Geno Ferrero, Mark Corbridge and myself have recently taken part in teleconference calls with Shannon Stanfill, Executive Director of the Board of Registration, and representatives from the University of Wyoming WyGISC institute and WYGEO organization. This collaboration focuses on getting us in front of more middle and/or high school students by better meeting teachers' curriculum requirements. We were introduced to "GeoInquiries", a new and interesting concept that can be used to demonstrate overlap of surveying with the various topics of study within the school curriculums. These GeoInquiries are designed to be 20-30 minute exercises, and examples can be easily found by online search of "ESRI GeoInquiries for schools".

There are plenty of exciting things going on within PLSW, and I am honored and excited to serve as President. I encourage all to be involved at the Chapter level to provide thoughts and input on these various topics to help guide our direction.

Lyle Casciato, PLS, CFedS
President, Professional Land Surveyors of Wyoming

ANNOUNCEMENTS

CONGRATULATIONS!

The members of the Professional Land Surveyors of Wyoming would like to recognize the achievement of the following new Wyoming registrants:

Ryan Wells	Wilson, WY	LS 16884
Wrangler Grohs	Sheridan, WY	LS 17009
Jesse Frisbee	Worland, WY	LS 17010
Rick Byrem	Zephyr Cove, NV	LS 17034
Lucien Schaffer	League City, TX	LS 17035
Bradley Lipscomb	Rockdale, TX	LS 17047
Eric Sackett	Pinedale, WY	PELS 11802

“Journeys: One Individual’s Excursions into the Surveying and Mapping Professions: Volume I”

by Herbert W. Stoughton

Price: $30.00 (includes S&H)
Proceeds from the sale will be invested in the PLSW Scholarship fund.

Send orders to:
2821 Carey Avenue, Cheyenne, WY 82001

Wyoming Lawmakers pass correction to Prexy’s Pasture precept

LARAMIE-It was, perhaps, one of the Legislature’s least consequential laws passed this session, which gave House Bill 91 an opportunity for some alliterative fun among legislators aiming to fix an error in Wyoming’s statutes regarding Prexy’s Pasture.

The University of Wyoming is barred under statute from constructing buildings on Prexy’s Pasture, the campus’ main quad.

Sen. Fred Baldwin, R-Kemmerer, who co-sponsored H.B. 91, said a UW student recently noticed the statute provides an incorrect description of where Prexy’s Pasture exists.

In one part of the legal description, statute incorrectly describes a boundary of Prexy’s Pasture as heading “north 84 degrees 16′ east.”

The statute’s original drafters meant “south 84 degrees 16′ east,” and the error means state statute has unwittingly included an area of campus with buildings as an area barred from having buildings.

Gov. Mark Gordon has now signed the bill into law, known as “Patching Prexy’s Pasture parallelogram problem,” which changes only one word in statute.

Source: Cheyenne Tribune-Eagle

Magnetic North Pole In On The Move

WASHINGTON - North isn’t quite where it use to be. Earth’s north magnetic poles has been drifting so fast in the last few decades that scientists say that past estimates are no longer accurate for precise navigation. On Monday, they released an update of where magnetic north really was, nearly a year ahead of schedule.

The magnetic north pole wanders about 34 miles a year. It crossed the international date line in 2017, and is leaving the Canadian Arctic on its way to Siberia.

The constant shift is a problem for compasses in smart phones and some consumer electronics. Airplanes and boats also rely on magnetic north, usually as backup navigation, said University of Colorado geophysicist Arnaud Chulliat, lead author of the newly issue World Magnetic Model. GPS isn’t affected because it’s satellite based.

Since 1831 when it was first measured in the Canadian Arctic it has moved about 1,400 miles toward Siberia. Its speed jumped from about 9 mph to 34 mph since 2000.

Source: Cheyenne Tribune-Eagle; 5 February 2019; p. A8.

New P.L.S.W. Logo Jackets

Men's Port Authority

The Port Authority jacket is constructed from a polyester stretch woven shell, which is then bonded to polyester microfleece with an added laminate film insert to repel water. Wind-resistant, water-resistant with stretch perfect for corporate or weekend wear.

Ladies Port Authority

The Young Gun is a 100% microfiber water resistant jacket. Has a western yolk accents on front and back. Features double snaps on waist, leather Velcro *closures* on cuffs and zippered underarm vents. Concealed hood and 3 exterior pockets and 4 interior pockets.

STS Jacket Young Guns

(Men's Sizes Only)

Back of Jacket
(8-1/4 inch diameter)

Front Left Chest
(3-3/8 inch diameter)

***Mail completed form with Checks**

Payable: Frontier Marketing

PO Box 2477
Cheyenne, WY 82003
Attn: Randy Rhodes
Questions Call: 307-778-1430

Port Authority $65.00 XS-XL
Port Authority $70.00 2XL-4XL
STS Jacket $125.00 XS-XL
STS Jacket $130.00 2XL-4XL

*** Shipping $15.00 per jacket (Cheyenne orders delivered)**

Customer Name: ____________________________

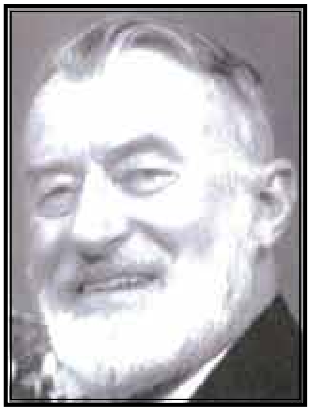
Shipping Address: ______________________________

PLSW contacts:
John Lee; jlee9901@aol.com; 307-760-0335
Suzie Sparks: s75spark@blm.gov; 307-775-6225
No shipping charge for Cheyenne address.
Printable order form available at www.plsw.org

Name Left Chest: ______________________ ☐NO NAME ☐NO BACK LOGO ☐NO FRONT LOGO

Size	XS	SM	MED	LG	XL		2XL	3XL	4XL		$ TOTAL
MEN'S	N/A					$65				$70	
LADIES						$65				$70	
STS						$125				$130	
SHIPPING						$15 PER				$15 PER	

Robert Corbet I 1937-2019



Robert Clyde Corbet, 81, of Burns passed away Jan. 3 with his family by his side.

Robert was born March 7,1937, in Pawnee City, Neb., to Robert F. and Louise B. (Patch) Corbet.

Robert attended college in Casper and received a degree with which he practiced land surveying for more than 40 years.

He married Dorothy Mae "Dottie" Hill on Aug. 24, 1957, in Casper. They traveled extensively with his work until purchasing the family farm, his lifelong dream, during which time he also owned his own land surveying business in Cheyenne.

Robert was an active member of Golden Prairie Baptist Church and a wonderful friend to all in the community. Papa loved all animals, especially dogs, and they in turn loved him.

Robert is survived by his loving wife of 61 years; his daughter, Deborah (Jeff); his sons, Randall (Lisa) and David (Doreen); 10 grandchildren; 12 great-grandchildren; and one great-great-grandchild.

He was preceded in death by his parents; a sister, Eleanor Wagers; and many beloved pets.

A memory service will be celebrated at 10:30 a.m. Saturday at the Burns-Plex in Burns, with Pastor Jeff Giles officiating. Cremation is under the care of Schrader, Aragon and Jacoby Funeral Home.

Condolences may be offered to the family online at www.schradercares.com.

This is a paid obituary.
Wyoming Tribune Eagle; Jan. 9, 2019

My papa was a Godly man who taught me many things. He taught me that anything worth having is worth working for. Laziness was not an option for us as kids. He also taught me I could be anything I wanted. He said there was no limit to what I could be. As a young girl, knowing that your hero believes in you that much means the world. When I was struggling in algebra he gave me his HP 12C calculator and taught me how to write formulas with it. I never did become a mathematical genius, but I always knew he thought I could be. I never knew how much that calculator would mean to me until now. I'm eternally grateful for the wisdom and love he has given me. I'm proud that he was my grandfather and strive to be like him every day.

Moniet Flores,
granddaughter of Bob Corbet

BLM NEWS

This letter is to inform you of the official cadastral surveys that were approved in Wyoming in 2018 and have been published to BLM Wyoming's Cadastral Survey website. Copies of the surveys can be viewed and/or printed from this website: http://www.wy.blm.gov/cadastral/plats18.htm

Township and Range	Type of Survey	Meridian	Accepted
T. 12 N., R. 113 W.	Dep. Res. & Survey	6 P.M.	01/11/2018
T. 46 N., R. 81 W.	Dep. Res. & Survey	6 P.M.	01/11/2018
T. 51 N., R. 66 W.	Dep. Res. & Survey	6 P.M.	01/25/2018
T. 18 N., R. 84 W.	Dep. Res. & Survey	6 P.M.	01/25/2018
T. 42 N., R. 83 W.	Dep. Res. & Survey	6 P.M.	01/25/2018
T. 20 N., R. 94 W.	Dep. Res. & Survey	6 P.M.	01/25/2018
T. 50 N., R. 102 W.	Supplemental Plat	6 P.M.	01/25/2018
T. 18 N., R. 105 W.	Dep. Res. & Survey	6 P.M.	07/02/2018
T. 21 N., R. 102 W.	Dep. Res. & Survey	6 P.M.	07/02/2018
T. 14 N., R. 78 W.	Dep. Res. & Survey	6 P.M.	07/02/2018
T. 33 N., R. 69 W.	Dep. Res.	6 P.M.	07/02/2018
T. 42 N., R. 113 W.	Dep. Res. & Survey	6 P.M.	07/02/2018
T. 3 N., R. 2 W.	Dep. Res. & Survey	W.R.M.	07/02/2018
T. 33 N., R. 68 W.	Dep. Res. & Survey	6 P.M.	07/02/2018
T. 57 N., R. 74 W.	Dep. Res. & Survey	6 P.M.	11/08/2018
T. 32 N., R. 70 W.	Dep. Res.	6 P.M.	11/08/2018
T. 27 N., R. 90 W.	Dep. Res. & Survey	6 P.M.	11/08/2018
T. 47 N., R. 78 W.	Supplemental Plat	6 P.M.	11/08/2018
T. 51 N., R. 70 W.	Supplemental Plat	6 P.M.	11/08/2018
T. 22 N., R. 93 W.	Supplemental Plat	6 P.M.	11/08/2018
T. 40 N., R. 66 W.	Remonumentation	6 P.M.	11/08/2018

A Millennial's View of Land Surveying

By Anthony Whitlock, LSI

Originally Printed in
XYHT: *Field Notes*

The author surveying in the field.

Mentors Are Needed

We are allowing time, money, technology, and workload to dictate how we train the newer generations of surveyors.

It used to be that a novice surveyor worked alongside the same party chief for about four years or so before he or she possessed the knowledge and skills to become a party chief themselves. That is at least four years of daily field calculations, boundary evidence gathering, stakeouts, topo surveys, and, most importantly, questions. These days, many surveying and engineering firms are teaching their field surveyors just enough so that they can take their data collector to the field and throw stakes in the ground.

This generation of surveyors is missing a gigantic piece of what was once the professional standard, the one-on-one mentorship and guidance with someone who knows much more than they do. It is your responsibility as a professional land surveyor to make time to teach your subordinates in a similar manner in which you were taught as a junior surveyor.

Every PLS should make it a personal goal to help develop truly skilled professionals and not just someone who knows how to operate a data collector. Sit down with them, review plats, discuss what should be done when they are unable to find monumentation in particular situations, explain how mistakes can be prevented by taking check shots or making sure a tie in point elevation matches the plan set, etc.

Depending upon what type of company you work for, you may have to do some of this on your own time, and I fully understand that sometimes it just isn't ideal for you, or for the junior surveyor, but it is our responsibility to make the profession as good as it can be. To me, that means that we are responsible for training our people appropriately.

Educational Requirements

These are a major deterrent for many young surveyors. Simply put, someone who does not enjoy school and who really has no intentions of achieving an associate or bachelor's degree is almost guaranteed to not get involved in, or stick with, the surveying profession if a degree is required for licensure.

There is now a limit placed on how high that individual can climb within the industry because he or she will never be able to achieve their professional licensure within most of the United States. I know some of you are probably thinking, "Well, we don't really want someone involved in our profession who isn't willing to work for a degree," and I suppose that is certainly a fair train of thought. However, I firmly believe that a person does not need educational credentials to become a great land surveyor. What they will need is a passion for the profession, a thirst for knowledge, and about a decade of real-world experience.

The above-described individuals are not the only ones whom we as a community have now steered away from the profession. Even men and women who plan to attend college now have a serious decision to make about their education and futures. It is no secret that on average civil engineers make more money than surveyors, and when these people are deciding what they want to go to school for, what professional track do you think they are going to choose when the cost of a four-year degree is the same and the field of study is within the same industry?

I understand wanting to make the profession as good as it can be and filling it with educated minds. However, the truth is that we have created a burden for potentially great surveyors, and I don't doubt that we have lost the interest of many who would have turned out just fine.

Staying up to Date

Continuing Education Units requirements (CEUs) are one of the best ways that we can ensure that fellow professionals are staying up to date with technology advancements, changes to state laws or national standards, and generally important information related to the profession. This requirement is enforced by state law and typically regulated by the state's governing surveying board (board titles vary state to state) and is put in place so that licensed professionals are required to attend a certain amount of continuing education courses in order to renew their professional license.

This means that every single licensed land surveyor is required to learn or refresh their knowledge within a multitude of different topics related to the profession, within a particular timeline set forth by said board. While most states that do currently require CEUs have instituted an annual or biannual licensure renewal timeline, I would like to see some states adopting a three- to five-year timeline instead.

I feel that requiring CEU submittals for licensure renewals on a biannual (or less) basis creates more problems for the professionals than it resolves. (Aside from possible counterproductive timeline requirements, I do feel that CEU requirements will provide a professional surveyor an excuse to take a course on a subject that he or she doesn't fully grasp or that they otherwise may not ever familiarize themselves with.)

I think there are quite a few surveyors out there operating this highly complex equipment without having nearly a firm enough understanding of how it truly works. If you believe that you have a firm understanding of GNSS equipment, quiz your field crews and see that they share your understanding.

It is just as, if not more, important that they comprehend what they are doing in the field with this equipment as it is that you do. With CEUs as a requirement, the professional is almost guaranteed to improve their comprehensive knowledge and understanding without the heavy burden of affording a college degree.

You may know a lot. You may even know everything, but if your field crews are not taken care of and are not being groomed as if to—maybe one day—have your position in the company, then their work will either inevitably be flawed, or you will never see them grow to their full potential. In today's surveying world, having a knowledgeable and skilled party chief is just as important as having an excellent professional surveyor.

It is your license on the line. Your party chief may know how to locate the rebar with the shiny new cap in the ground but may have had no idea that the 80-year-old fence line 10 feet away could have mattered as well. The next generation of licensed surveyor's skills, competencies, and professionalism are heavily dependent upon the values, work ethic, and follow-through that you instill into them as being the standards for our profession.

It is imperative that we do not let deadlines and money pull us astray from the overall greater good of our work.

Geodetic Surveying: Part XVI

Alexander Dallas Bache and the Coast Survey: Part 5

Herbert W. Stoughton, PhD, PELS, CP

With the reorganization of the Coast Survey (1843), the second superintendent, Alexander Dalles Bache, immediately initiated efforts to raise the stature of American science both in the United States and throughout the world. Bache's education at West Point (one of the leading engineering academic programs in the United States) and his pre-Coast Survey career, provided invaluable insight into engineering and natural physical science. To that end, Bache directed the science and engineering endeavors by the military, naval, and civilian assistants working within the Coast Survey, and distributed "patronage" to prominent American scientists and organizations. These activities influenced political awareness and awakening of the American scientific community through the American Association for the Advancement of Science and the formation of the National Academy of Science.

During the Hassler tenure, the Coast Survey was not a scientific organization, but an engineering organization collecting geographical and geophysical facts. The amounts of collected data and facts were of a scale never before witnessed. The information was rapidly processed, classified, and organized. Then, an excellent distribution system communicated the findings to an interested audience. This information greatly contributed to the budding academic disciplines of geophysical phenomena, physical oceanography, marine geology, marine biology, and meteorology. Five activities which supported these claims were: (1). discovery of local gravitational anomalies caused by different crustal densities as determined by comparing geodetic distances (from triangulation) with astronomically determined positions (1851); (2). discovery of the continental shelf break from the Gulf Stream expeditions (1849, 1851); (3) definition of the nature of the tides on all the coasts (1853); (4) discovery of submarine canyons during west coast sounding operations (1857); and (5). discovery of bands of relatively cold water in the Gulf Stream (1846). Although these were significant discoveries, with the exception of No. 1, the other items were minor contributions to the Coast Survey's statutory assignment.

The Coast Survey's activities impelled it into an intellectual realm placing an increasing requirement for refined measurements, systematic methods to collect the measurements, and mathematical analysis to extract the best answer (sometimes called truth) from the information. Much of the collected data led to angles, distances, and geodetic or astronomic positions. These quantities are best seen (viewed) through the medium of mathematics.

Hassler realized that absolute mathematical accuracy is a figment in the mind of man. Practical applications are approximations. It is imperative for the observer to recognize the instrumental defects which cause departure of the observed data from the theoretical principles.

In the decade since Hassler's death, the philosophy of measurement and analysis had evolved. The numerous geophysical and geodetic endeavors required sophisticated analytical tools to contribute further insight into the nature of observational errors. In early work of the Coast Survey, application of the "indiscriminate mean" and "least squares" were unsatisfactory. Sears Cook Walker, Julius Erasmus Hilgard, and Charles Anthony Schott had grasped the principles and application of least squares to determine the most probable value of observed quantities.

One of the first personages on the scene was Benjamin Peirce, Professor of Mathematics, Harvard University (4 Apri1809 - 6 October 1890). Peirce authored a "Criterion for Rejection of Doubtful Observations" (The Astronomical Journal; No. 45, V. II, No. 21; 24 July 1852). Peirce authored a paper in the Coast Survey report for 1854 entitled; "Report Upon the Determination of Longitude by Moon Culminations" (Appendix 36; pp. 108 - 120). The paper contained a discussion of the various types of observational errors and an understanding of the ultimate limits of accuracy. Although Peirce's theme addressed lunar culminations, his underlying tenets introduced, through the Coast Survey, American science to this method of operation/observation. These were: (1). establish (design) procedures and standards for repeating observations of the phenomena in a disciplined, systematic manner; (2). statistically analyze the observations to determine a most probable value of the observed phenomena and

Lines and Points Article Rotation Submission Schedule By Chapter

Responsible Chapter	First Call Date	Last Call Date	Publication Date
Upper Platte Chapter	June 1	June 15	July 1, 2019
Southwest Chapter	September 1	September 15	October 1, 2019
Northeast Chapter	December 1	December 15, 2019	January 1, 2020
Northwest Chapter	March 1	March 15	April 1, 2020
West Chapter	June 1	June 15	July 1, 2020
Central Chapter	September 1	September 15	October 1, 2020
South Central Chapter	December 1	December 15, 2020	January 1, 2021
Southeast Chapter	March 1	March 15	April 1, 2021

the associated error bounds; (3). identify sources of errors (or potential sources of error) and means to mitigate these errors; (4). comprehend that there is a limit to the "ultimate accuracy" of any system of observation, and if the limit is unacceptable, then the observer must devise/design a new and better system; and (5). with the new system, repeat the process until attaining the desired results.

These precepts were employed to the following types of problems: (1). to determine the "most probable values" to assign to measured or derived "fixed" quantities; and (2) the second class involved prediction by mathematical modeling. These methods were to predict the state of transient phenomena such as tides, currents, magnetic field components' changes. This approach had not been utilized by the American scientific community. After the publication of the 1854 Annual Report, the subsequent Coast Survey reports contained descriptions and procedures to apply these principles. The American scientific community translated/transferred the procedures and methodologies into their own scientific studies.

On 7 August 1826, at Mannheim (Duchy of Baden) Charles Anthony Schott was born. Schott spent six years at Carlrube Polytechnic, graduating second in his class in civil engineering. Three years prior to Schott's admission to the Carlrube Polytechnic, Professor Alexander D. Bache visited the institution during his European tour. At the age of 21 years, Schott sought employment as a railroad engineer. However, due to the political unrest in Germany, and he was not impressed with military life (with the liberals), Schott departed to America on 15 June 1848 (at 21 years of age and having about $150 in his pocket). Schott arrived in New York on 8 August 1848. Schott kept meticulous chroniclers of his personal experiences.

Schott carried letters of introduction to Theodore E. Hilgard, an eminent German jurist and author who had earlier immigrated to the United States. Hilgard's eldest son, Julius Erasmus Hilgard, had moved to Philadelphia in 1843 to study civil engineering. The younger Hilgard encountered Superintendent Bache. Impressed with Hilgard's abilities, Bache hired Hilgard as a civilian assistant in the Coast Survey, and he introduced Schott to Bache. On 8 December 1848, Schott was appointed an assistant. Bache (at the age of 37 years) Hilgard (23 years) and Schott (22 years) would, during their careers at the Coast Survey, leave indelible influences on that organization during their careers.

Within five years, Schott would author five scientific papers that identified him as a formidable geodesist and scientist. The first paper he coauthored (with Lt. Edward Bissell Hunt, U.S. Army) was titled: "Tables for Projecting Maps With Notes on Map Projections." Three of the papers addressed tides and currents. The fourth paper was titled "Adjustment of Horizontal Angles of a Triangulation" and published in the Annual Report for 1854. (Appendix 33; pp. 70 - 95). In this paper, Schott identified and classified the errors in triangulation into two categories: (1), "Disagreement of the Observations Among Themselves"; and (2). "Discrepancies Exhibited by the Geometrical Conditions of the Triangulation Not Being Strictly Fulfilled by the Observed Quantities".

Another problem that Bache and the Coast Survey assistants had was to take collected observed data and formulate methods of predicting future states and deriving past states of transient phenomena. The transient phenomena first addressed were tides, currents, and geomagnetic parameters. Although these phenomena were important, the prediction of tides would continuously be addressed for the next 150 years.

The first in depth general study of tides were published by William Whewell (24 May 1794 - 6 March 1866), who wrote 14 papers on tides between 1833 and 1850. His ultimate goal was to attempt to find a solution to predict tides. Although one of the foremost nineteenth century English mathematicians, Whewell gave up the quest. The Coast Survey assistants took up the challenge.

In the late 1840's, Lt. Charles Henry Davis used Whewell's graphical methods for the observed tide at Old Point Comfort, Virginia. Assistant Henry Mitchell introduced Sir John William Lubbock's (26 March 1803 - 21 June 1865) tidal work for which he was awarded the Royal Medal (1834). Assistant Ferdinand H. Gerdes, while working along the Gulf of Mexico (1845), reported about tidal phenomena. Assistant Gerdes was aware of the inter-relationship of tides, currents. and local meteorology. He recognized the need for a long-term continuous observational program in order to develop a system of predictions. Bache openly welcomed these endeavors. He supported developing a comprehensive tide observational/reduction program which would eventually produce a first rate tidal prediction program.

In 1853, the Coast Survey published "Tide Tables for Use of Navigators, with Descriptions of Bench Marks, Explanations and Examples for Use" (A.D.

Bache; Report of the Superintendent; Appendix 26; pp. 67 - 70). Bache acknowledged that there was general agreement on the average, but in single cases, discrepancies were unsatisfactory. Bache had the errors analyzed, and recognized they were not random. Finally, Bache concluded that the problem should be addressed by mathematicians and physicists working in concert. Bache concluded that even though there were different theories describing tidal phenomena, the general form of the functions were identical. The same general results occurred, and that heights and times of high water could be described by certain functions, with indeterminate coefficients. By forming the equations from observations and obtaining numerical coefficients, the results are achieved. This procedure had been commonly employed in astronomical computations. The first test used 24 coefficients for the tides at Boston. In 20 pairs of tides observed as a test, errors ranged from two to ten minutes. The estimated probable error was slightly larger than four minutes!

Similar methods were developed for predicting currents and the elements of the geomagnetic field. Charles A. Schott's mathematical ability and superior computational abilities made him a pioneer and leader in these endeavors. Schott was quite successful in this mathematical modeling.

Benjamin Peirce, in "Report Upon Determining of Longitude by Moon Culminations" (Report of the Superintendent . . . 1854; Appendix 36; pp. 87 - 133), presented the observational and computational problems associated with many operations associated with modern science and engineering. These are: (1). establish procedures and standards for repeating measurements of a phenomena in a disciplined systematic manner; (2) statistically analyze the measurements to compute a most probable value and estimate its associated error bounds; (3). identify sources of error and means to mitigate and/or eliminate these errors; (4). comprehend that there is a limit to the ultimate accuracy of any system of observations, and if the limit is unacceptable, devise a new and better system; (5). with the new system, repeat the above process until obtaining the desired results.

Mathematical modeling depend on the aforementioned precepts (Peirce) had six corollaries: (1). conduct extended observations of the phenomena to be modeled; (2) generate a theory to explain the observed phenomena; (3). develop mathematical formulas and coefficients of terms consistent with the theory to describe the observed changes; (4). Use the theory and mathematical formulas to predict the future state of the phenomena; (5). test the prediction against real world observations; and (6). if the resulting model does not agree sufficiently with "real world", develop a new model and/or new theory in order to iterate to a better fit to the observations.

Peirce's paper "Criterion for the Rejection of Doubtful Observations" responded to how to attack the problem of identifying suspected outliers in computing prediction formulas, but Peirce's criterion was not universally accepted by the scientific community. The underlying mathematics was eventually disproved approximately six decades after the original publication [R.M. Stewart; 1920; Popular Astronomy; V. 28; pp. 2 - 3].

Bache and his assistants did not create the theories and mathematics which became the back bone of their successes in tidal prediction, marine currents, and magnetic variation. They searched through the writings of the European and American scientific communities. The Coast Survey's contribution was the ability to assemble a cadre of dedicated assistants (Army, Navy, and civilians) to address these problems. In less than 15 years they had amassed a data set necessary to postulate, design, test, re-evaluate, and refine the model. Hassler and Bache demanded superior quality observations and data, and supporting correlative information having potential effects which would refine the results.

Starting in the early to mid 1840's, Bach; Joseph Henry (17 December 1797 - 13 May 1878); Jean Louis Rodolphe Agassiz (28 May 1807 - 14 December 1873); Adm. Charles Henry Davis (16 January 1807 - 18 February 1897); Benjamin Anthorp Gould (27 September 1824 - 26 November 1876); and Benjamin Peirce formed a very exclusive clique in the American scientific community. Dr. Agassiz was born in Switzerland, migrated to the United States, and took up professional residence at Harvard University. His specialty was paleontology and naming extinct species. Admiral Davis joined the Navy, was assigned to the Coast Survey, discovered navigation hazards on the Atlantic coast, and collected invaluable tide and current data. He was the first superintendent of the American Nautical Almanac Office (1849 - 1855) and superintendent of the Naval Observatory (1865 - 1867). At a young age, Joseph Henry discovered/developed the theory of magnetism. He was the first director of the Smithsonian Institution. Dr. Benjamin Anthorp Gould was the first American to earn a doctorate under Carl F. Gauss. Back in

the United States, Gould became an assistant at the Coast Survey and was in charge of astronomic work (determination of longitudes) (1852 - 1867). Gould was one of the first astronomers to determine longitudes by telegraphic time signals. He employed the trans oceanic Atlantic cable to transfer longitude/time from Europe. In 1859, Gould published a discussion of the apparent places and proper motion of circum polar stars to be used as the standard stars by the Coast Survey. In 1868, he organized and became first director of Observatorio Astronómimco Córdoba (Argentine). While in Argentina, Gould and four assistants extensively mapped the southern skies using photometric methods (stellar photogrammetry). Gould's work on stellar photographs in 1866 made him a pioneer in this accurate endeavor to determine star position and proper motion.

These men defined the ethics, soul, and conscience for American science. In 1838, Henry expressed his concerns about professional standards in the American science community. He referred to the tendency to embrace "charlatans". In this letter, Henry described the "wonderful sensation produced in the country by magnetic machines". A company was formed which procured $ 12,500 for experiments. After much "puffing" and "expenditure of funds the entire project fell through . . .". The leader of the mater was a Dr. Sherwood. Henry's letter continued describing the entire affair. Although Henry had made his reputation in the theory and application of magnetism, his commentary was not "sour grapes" for not obtaining a research grant. His concerns were about "professional integrity".

In late 1847, the Association of American Geologists and Naturalists conferred with Agassiz in forming an organization representing all facets of American science. The new organization was the American Association for the Advancement of Science (AAAS). William Charles Redfield (6 March 1789 - 12 February 1857) was the first president. The AAAS's intent was to elevate the stature of American science. The organization would quickly become a major political player in supporting scientific endeavors. It avidly supported the Coast Survey and other scientific endeavors, which significantly contributed to the leadership role of theoretical and applied science.

The inner group of scientists (listed earlier), and others, realized that AAAS could not establish or enforce scientific standards. The political crisis of 1860 would serve as an impetus. The early years of the American Civil War witnessed a static and confused attitude by political entities as to the importance of science. Henry did not support formation of a commission to evaluate inventions and scientific proposals. However, the remainder of the clique disagreed with Henry. They enlisted the support of Senator Henry Wilson (Massachusetts). On 21 February 1863, Senator Wilson introduced a bill identifying 50 scientists to comprise a National Academy of Sciences (NAS). The bill was signed in early March. The selection of the original members produced controversy.

Bache was elected the first president of the NAS. However, he did not play a leading role, because in 1864 he became physically incapacitated. In May 1864, Bache apparently suffered a stroke or other debilitating illness. After the incident, he was not influential in the American scientific community, and died in 1867. Bache, however, contributed to the success and survival of the NAS after his death. He willed his estate to NAS, and his friend Dr. Henry filled a leadership role by expanding the membership and transforming the group into a learned society.

While the death of Alexander Dalles Bache was a significant event in the history of the Coast Survey, the organization did not wither and suffer any lingering incapacity. Dr. Bache and F.R. Hassler had both, in their own ways, left indelible marks. From the initial formation and within both the Coast Survey and the Office of Weights and Measures there was developed and infused high standards established for instrumentation and equipment; implementation of exacting scientific and mathematical theories; observation and collection of refined data/information; and presentation/publication of the results. Both superintendents sought and nurtured individuals who understood these exacting standards. Both superintendents demonstrated strong personal commitments when the Coast Survey was under attack by unscrupulous politicians desiring to dismember the organization. The Coast Survey had developed the highest standards for collecting information and producing the end-products. Henceforth, the organization would continue and maintain this level of excellence. In the future, the Coast Survey (and its successors) would attract very competent men and women who would continue the Coast Survey traditions; continue development of the science and applications of geodesy and geophysics; and become recognized nationally and internationally for their work.

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